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February 1998

US Army Corps
of Engineers
Waterways Experiment
Station

# Guadalupe River and Bypass Culvert, San Jose, California

## Hydraulic Model Investigation

*By John E. Hite, Jr.*



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Prepared for U.S. Army Engineer District, Sacramento

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Final report



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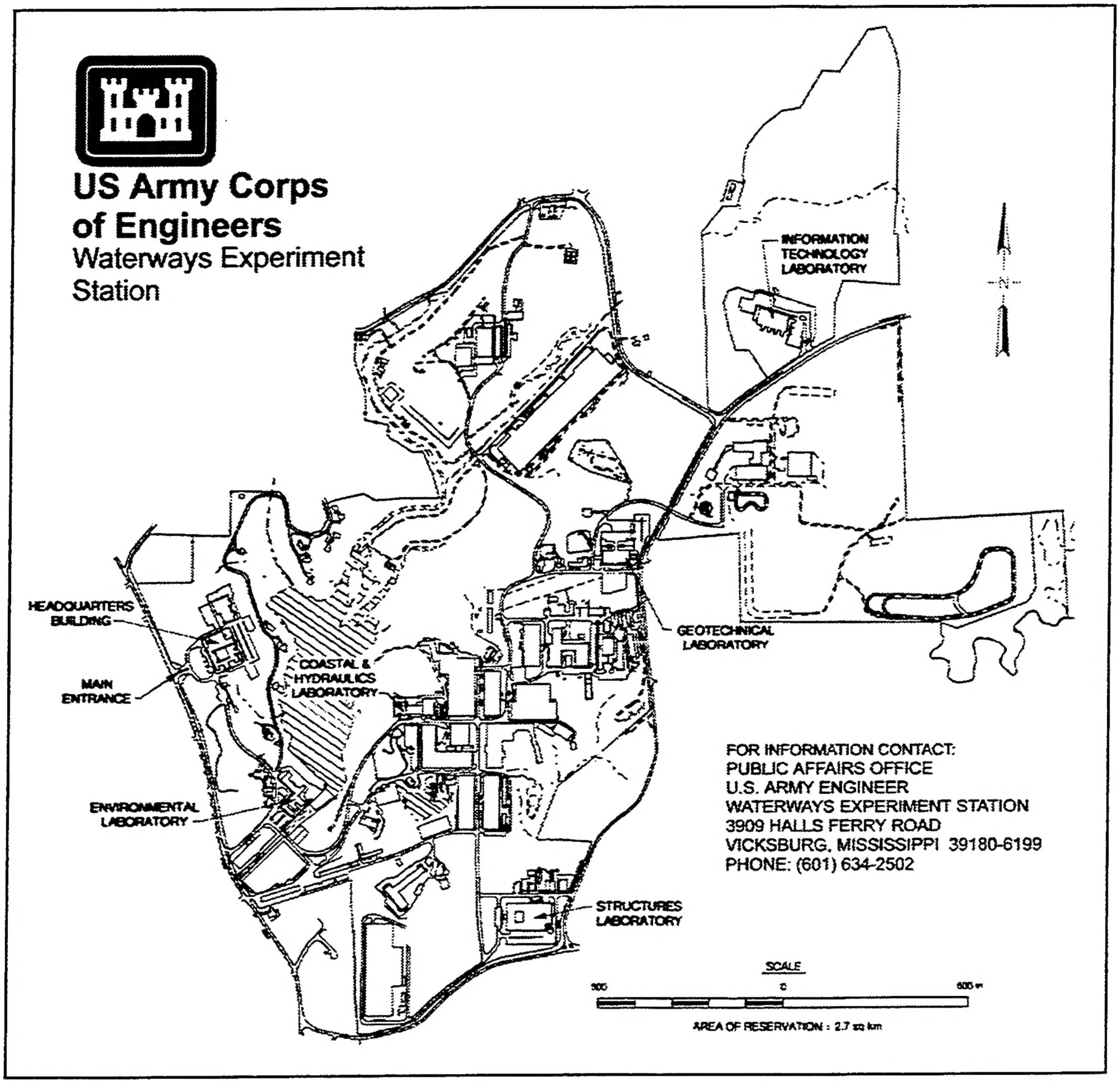


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# Contents

# Preface

This report presents the results of a model investigation authorized by Headquarters, U.S. Army Corps of Engineers, on 21 May 1992, at the request of the U.S. Army Engineer District, Sacramento (SPK). The model experiments were performed during the period February 1993 to February 1996 by personnel of the Hydraulics Laboratory (HL) of the U.S. Army Engineer Waterways Experiment Station (WES) under the general supervision of Messrs. Frank A. Herrmann (retired) Director, HL; Richard A. Sager, Acting Director, HL; Robert F. Athow, Acting Assistant Director, HL; Glenn A. Pickering (retired), Chief, Hydraulic Structures Division; and John F. George, Acting Chief, Hydraulic Structures Division. Dr. Phil G. Combs is current Chief of the Hydraulic Structures Division.

Experiments were conducted by Mr. Glenn Davis, Dr. Richard Stockstill, Messrs. Marshall Thomas, James Cessna, Joe Myrick, and Dr. John Hite, Jr., of the Hydraulic Structures Division under the supervision of Mr. John F. George, Chief of the Locks, Reservoirs, and Fisheries Hydrodynamics Branch. In October 1996, HL merged with the WES Coastal Engineering Research Center to form the Coastal and Hydraulics Laboratory (CHL). Dr. James R. Houston is the Director of the CHL and Messrs. Richard A. Sager and Charles C. Calhoun, Jr., are Assistant Directors. This report was written by Dr. Hite and Ms. Debra Katzenmeyer, CHL, assisted in report formatting and word processing.

The model was constructed by the WES Model Construction Section under the supervision of Mr. T. Lee, Jr., and the Model Shop under the supervision of Mr. E. A. Case (retired).

During the course of the model study, Messrs. Charles Mifkovic, Dave Ruark, Erik Halsted, Tom Marstein-Marx, and Harold Huff, SPK, and Mr. Frank Khroun of the South Pacific Division visited WES to discuss experimental results. Messrs. Scott Katric and Randy Talley of the Santa Clara Valley Water District, Mr. Art Woodworth from A-N West, Inc., Mr. Robert Ryan from the San Jose Redevelopment Agency, and Ms. Mary Margaret Jones from Hargreaves Associates also visited WES to view the model and discuss model results.

Director of WES during the preparation of this report was
Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

# Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

| Multiply | By | To Obtain |
|---|---|---|
| cubic feet per second | 0.02831685 | cubic meters per second |
| cubic yards | 0.7645549 | cubic meters |
| feet | 0.3048 | meters |

# 1 Introduction

## The Prototype

The area of the Guadalupe River reported on herein is located in San Jose, California, immediately south of San Francisco Bay (see Figure 1). The U.S. Army Corps of Engineers is designing and cost-sharing channel improvements on the Guadalupe River to provide flood protection for the 1-percent exceedance event.

The channel reach that required physical modeling extends approximately from near the confluence of Los Gatos Creek with the Guadalupe River to upstream of the I-280 overcrossing. This includes the existing box culvert bypass that parallels the channel from I-280 to just downstream of Park Avenue. Model limits are shown in Plate 1.

Much of the channel reach was modeled previously at The U.S. Army Engineer Waterways Experiment Station (WES) in 1988 as part of the General Design Memorandum (GDM) studies. Since that time, modifications to the flow split between the box culvert and the natural channel at the I-280 overcrossing and the natural channel in other areas have been made to include aesthetic and architectural treatments. These modifications were significant enough to impact flow conditions and another model was considered necessary to evaluate these impacts. Only portions of the box culvert used in the previous study were used in the new model.

## System Elements

### Approach channel

The Santa Clara Valley Water District (SCVWD) has proposed an upstream project for bypassing future flood flows in a bypass channel. For this reason, it was necessary to investigate two approach flow conditions at the upstream end; (a) existing conditions, and (b) the proposed project by SCVWD. With existing conditions, the natural channel abruptly transitions to the project channel at the upstream end of the project limit, Sta 199+24. Right overbank flows are collected in a shallow channel which carries the flows to the project channel at the I-280 overcrossing. A weir on the left bank directs overbank flows, which pond at the I-280 interchange into the project channel. The left bank weir is located opposite of

the right overbank inflow into the project channel. The future upstream condition will consist of the upstream SCVWD project, which will include a bypass channel. This bypass channel and the existing channel will together convey the 1-percent exceedance flow. This channel merges with the natural channel at the upstream limit of the Corps project. With the proposed project, no overbank flows would occur with the 1-percent exceedance event.

### Bypass culvert and intake

The intake structure to the box culvert consists of an ogee weir 6.28 ft[1] high and on a curved alignment. Flow over the weir enters a rectangular concrete channel 50 ft wide and 317 ft long. This concrete channel carries the bypassed flow to an existing 50-ft-wide double-cell box culvert. The downstream end of the box culvert extends 96 ft to where the bypassed flows will merge with the flow in the natural channel. The box culvert was designed with a Manning's n value of 0.014.

### Natural channel

Flows not bypassed to the box culvert will continue down the natural channel and rejoin the bypassed flow downstream from Park Avenue. The natural channel from the bypass culvert to Park Avenue is 2,400 ft. The first 680 ft to just downstream of Woz Way is subject to high velocities. Bank protection from downstream of the weir to downstream of Woz Way will be gabion baskets below the main riverwalks and stone terraces with gabion infill above.

### Main channel

The main channel from the Park Avenue confluence to the Santa Clara St. Bridge is similar to the 1988 model. The primary change was to the right bank, which was given a scalloped appearance.

### Discharges

The 1-percent exceedance design flow for the portion of the project modeled is 14,600 cfs. For existing conditions (with overbank flows) and the design discharge of 14,600 cfs, an estimated 9,100 cfs enters from the natural channel, 3,500 cfs from the left overbank, and 2,000 from the right overbank. With future conditions and the design discharge of 14,600 cfs, an estimated 4,800 cfs enters from the natural channel and 9,800 cfs enters from the bypass channel. The flow distribution with the SCVWD project in place for lower discharges is provided below.

[1] A table of factors for converting non-SI units of measurement to SI units is presented on page vii.

| Discharge, cfs | | |
|---|---|---|
| Natural Channel | Bypass Channel | Total |
| 1,500 | 0 | 1,500 |
| 1,600 | 4,900 | 6,500 |
| 2,600 | 6,300 | 9,100 |

### Design constraints

The primary project constraints as provided by the U.S. Army Engineer District, Sacramento (SPK) are listed below.

*a.* The water-surface at the upstream project limit (Sta 199+24) should not exceed elevation 90.0.

*b.* A flow of 1,500 cfs should be discharged down the natural channel before flow over the ogee weir into the bypass culvert begins.

*c.* At the design discharge of 14,600 cfs, 8,100 cfs should be diverted to the bypass culvert and 6,500 cfs should be carried by the natural channel.

*d.* The desired clearance underneath the bridges in the modeled reach should be a minimum of 1.0 ft with the design discharge of 14,600 cfs.

*e.* The desired clearance from the water surface to the top of the bypass culvert should be a minimum of 1.0 ft with the design discharge.

*f.* The project should remain functional if the water-surface elevation in the natural channel varies due to sensitivity resulting from channel roughness and/or sediment depositional effects.

### Purpose and scope of model investigation

The physical hydraulic model study of the elements described previously was considered necessary for the following reasons:

*a.* To determine the flow distribution between the natural channel and the bypass culvert and make modifications to ensure the desired flow distribution was achieved for the range of discharges, especially the design discharge.

*b.* To evaluate the flow conditions in the box culvert and make sure unstable conditions such as excessive water-surface differentials or pressurized flows do not occur.

*c.* To determine the bridge clearances with the design discharge.

*d.* To determine the flow conditions in the vicinity of the piers and bridges.

*e.* To qualitatively evaluate the effect of sediment deposition during a flood hydrograph.

The maximum water-surface elevations underneath the bridges to be allowed by SPK with the 1-percent event (14,600 cfs) are listed below.

| Bridge | Target Elevation |
|---|---|
| Santa Clara St. | 77.4 |
| San Fernando St. | 80.6 |
| Park Avenue | 82.1 |
| San Carlos St. | 83.8 |
| Woz Way | 88.2 |

# 2 The Model

## Description

The 1:25-scale model reproduced approximately 1 mile of the project beginning upstream of the I-280 overcrossing, sta 204+00, to downstream from the Santa Clara Bridge, sta 149+50, including the 50-ft-wide box culvert that parallels the channel from I-280 to just downstream of Park Avenue. The model layout is shown in Plate 1 and dry bed photographs of the model after construction are shown in Figures 2-10. The natural channel was molded in sand and cement mortar to sheet metal templates. The bypass culvert was constructed of plastic with some of the invert transition molded in sand and cement, with a very smooth cement finish.

The prototype box culvert was designed with a Manning's n of 0.014. To reproduce the roughness correctly in the model using the plastic material and the appropriate scaled length, the model slope requires adjusting. Since the bypass culvert ties back into the natural channel, adjusting the model slope could not be performed without a discontinuity in the model. To avoid a discontinuity in the natural channel, the invert slope was not changed and thus the energy gradeline of the flow in the box culvert was equivalent to one reproduced by a box culvert with a Manning's n value of 0.0154. This change in roughness was considered acceptable in order to avoid the discontinuity.

The model was constructed from numerous drawings furnished at various intervals throughout the investigation. The majority of the original model described in this report was constructed from the GDM plates dated December 1991. More specifically, the model from sta 204+50 to sta 199+24 was built from SCVWD drawings Guadalupe River I-280 to Blossom Hill Rd. Plan and Profile, sheet 7 (Natural Channel), and sheet 10A (Bypass Channel). From sta 200+00 to sta 193, the model was built from GDM Plate 3 with additional information near the access ramp at the weir provided by A-N West, Inc., drawings (Guadalupe River Park-Design Development Underlay (GRP-DDU sheet 13)). The box culvert from sta 1+56 to sta 11+32.9 was constructed from Sacramento District box culvert drawings labeled sheets 4, 5, 6, and 8. The box culvert from sta 11+32.9 to sta 9+55.7 was built from GDM Plate 6. The Guadalupe River from sta 193+00 to 176+94 was constructed from GDM Plate 4 with additional information provided in Guadalupe River-Riverwalk Improvements (GRP-RI) sheets 21, 22, 43, and 54. From sta 176+94 to 161+31, the model was built from GDM Plates 5 and 6 and GRP-RI sheets 23, 24, and 30. From sta 161+31 to sta 149+00, the model was constructed

from GDM plate 7 and GRP-DDU sheet 29. The information provided for modifications to the model will be identified when mentioned in the text.

## Model Appurtenances

Water used to operate the model was supplied by a circulating system. Discharges were measured with venturi and paddle-wheel flow meters installed in the inflow lines. The inflow was baffled before entering the model to provide the desirable upstream boundary conditions. Water-surface elevations were measured with point gauges, and velocities were measured with a propeller type meter mounted to permit measurements at any horizontal direction and depth. The tailwater was maintained at the desired depth by means of an adjustable tailgate. Dye and confetti were used to study subsurface and surface current directions. Various flow conditions were recorded with photographs and videotape.

## Scale Relations

The accepted equations of hydraulic similitude, based on Froudian relations, were used to express mathematical relations between the dimensions and hydraulic quantities of the model and prototype. General relations for the transfer of the model data to prototype equivalents, or vice versa, are presented in the following tabulation:

| Characteristic | Scale Relations Dimensions[1] | Model:Prototype |
|---|---|---|
| Length | $L_r = L$ | 1:25 |
| Area | $A_r = L_r^2$ | 1:625 |
| Velocity | $V_r = L_r^{1/2}$ | 1:5 |
| Discharge | $Q_r = L_r^{5/2}$ | 1:3, 125 |
| Volume | $V_r = L_r^3$ | 1:15, 625 |
| Weight | $W_r = L_r^3$ | 1:15, 625 |
| Time | $T_r = L_r^{1/2}$ | 1:5 |

[1]Dimensions are in terms of length.

Certain model data can be accepted quantitatively, while other data are reliable only in a qualitative sense because of the nature of the phenomena. Measurements in the model of discharges, water-surface elevations, velocities, and resistance to displacement of riprap material can be transferred quantitatively from model to prototype using the preceding scale relations.

# 3 Experimental Results

## Original Design (Type 1 Design) Without Roughness Elements

Initial model data were collected with the Guadalupe River channel molded of concrete with no roughness elements and without the Woz Way bridge pier installed. Flows were observed for existing conditions with discharges of 14,600 (1-percent exceedance flow) and 9,100 cfs. The 14,600-cfs discharge was distributed between the existing channel and the overbank inflow areas as mentioned previously, with 9,100 cfs entering the existing channel and the remaining flow entering through the right (2,000 cfs) and left (3,500 cfs) overbank areas. With a discharge of 9,100 cfs, all the flow entered the existing channel.

### Discharge 14,600 cfs

Flow conditions with a discharge of 14,600 cfs are shown in Photos 1-8. Confetti was used in these photos to highlight the surface flow patterns. The flow disturbances caused by the piers in the main channel upstream of the bypass culvert are evident in Photo 1. The flow was concentrated toward the left bank and the standing waves caused by the piers are shown in Photo 2. Flow over the ogee weir at the entrance to the bypass culvert is shown in Photos 1 and 2. The eddies and flow concentrations in the Guadalupe River channel are shown in Photos 3-8. Flow conditions at the confluence of the bypass culvert and natural channel are shown in Photo 6. A significant flow disturbance is caused by the pier located downstream from the confluence (GVC Bent 5A). Water-surface elevations measured in the river for existing conditions with a total discharge of 14,600 cfs are provided in Table 1 and water-surface profiles are shown in Plates 2-4. Flow depths measured in the bypass culvert are listed in Table 2 and water-surface profiles in the culvert are shown in Plates 5 and 6. Without the roughness elements in the model, the water-surface elevations in the river and the flow depths in the bypass culvert were acceptable. Bridge clearances were acceptable at all bridges except the Santa Clara St. Bridge.

Experiments were then performed to determine the flow distribution for existing conditions, the original design with no roughness elements, a discharge of

14,600 cfs and a tailwater elevation of 77.6. The results revealed that 37 percent of the total inflow, or 5,400 cfs, was diverted down the bypass culvert.

### Discharge 9,100 cfs

Flows with the original design for existing conditions, a discharge of 9,100 cfs, and a tailwater el of 73.9 are shown in Photos 9-16. Confetti highlights the surface eddies and areas of concentrated flow. The flow disturbances caused by the piers in the main channel were not as severe but were still evident, as seen in Photo 10.

Water-surface elevations measured in the river for existing conditions with a total discharge of 9,100 cfs and a tailwater el of 73.9 are provided in Table 3. Water-surface profiles measured in the river are shown in Plates 7-9. Flow depths measured in the bypass culvert are listed in Table 4 and water-surface profiles in the culvert are shown in Plates 10 and 11.

Experiments conducted for existing conditions, the original design, a discharge of 9,100 cfs, and a tailwater el of 73.9 indicated 40 percent of the flow, or 3,600 cfs, was diverted down the bypass culvert.

### Roughness experiments

Experiments were conducted to determine the appropriate roughness elements to install in the original design model to better represent the prototype roughness of the invert and sides of the channel. The natural channel has vegetation and trees on the side slopes and sand and gravel on the invert. SPK indicated that for a flow in the Guadalupe River of 1,500 cfs, the Manning's n for the channel should be 0.03, and the Manning's n value should be 0.05 for a flow of 6,500 cfs in the river.

Experiments were performed in a separate laboratory flume to determine materials that would reproduce these Manning's n values. The flume section used for the roughness experiments was 60 ft long and 5 ft wide. Since the Guadalupe River cross sections of interest were not similar, a representative section shown in Plate 12 and Photo 17 was molded in the flume for the experiments. Experiments were conducted with 1/16-in.-thick expanded metal placed on the invert and on the side slopes up to the 1,500-cfs waterline. The Manning's n value was determined from the Manning Equation

$$V = \frac{1.486}{n} R^{2/3} S^{1/2} \qquad (1)$$

where

$V$ = velocity in ft/sec
$R$ = hydraulic radius in ft
$S$ = slope of energy grade line in ft/ft
$n$ = Manning coefficient

The flow area was determined from the model experiments and R and V (given the discharge) were calculated. The expanded metal produced a Manning's n value of 0.03 with a discharge of 1,500 cfs. This was the value desired; therefore, additional experiments were performed to determine roughness elements needed to produce a Manning's n value of 0.05 with a discharge of 6,500 cfs in the river channel.

Initially, 1/2- in.-diam dowels were placed in the model in a single row at the 1,500-cfs waterline. Results indicated not enough roughness was accomplished with this design. Experiments were then conducted with various combinations of dowels and a rubberized horsehair material, in addition to the expanded metal. The combination that produced the desired Manning's n value was three rows of dowels on each side of the channel placed as shown in Plate 12 and Photo 17. Flow conditions in the research flume with a discharge of 6,500 cfs and the roughness elements are shown in Photo 18.

The wooden dowels were then installed in the Guadalupe River model in a similar arrangement on the appropriate bank(s). The dowels were placed on both banks between the Woz Way and San Carlos Bridges and on the right bank between the San Carlos and Park Avenue Bridges.

## Model with Roughness Elements (Type 2 Design)

The model elements reproduced an energy gradient for a Manning's n of 0.05 when the discharge in the natural channel was 6,500 cfs. With a discharge of 1,500 cfs, the model elements reproduced an energy gradient for a Manning's n value of 0.03. These modifications installed in the Guadalupe River were designated the type 2 design.

### Comparison with previous model study

Water-surface elevations were measured with a discharge of 1,500 cfs to compare with those obtained from a model study performed by Hydro Research Science (HRS), Inc. The comparison is shown in Table 5. The water surface at sta 190+00 was fixed at 79.25 by raising the tailgate at the downstream end of the model (sta 149+00). The station designations in the WES model were changed from those in the HRS study. For example, sta 202+70 in the WES model was sta 19+00 in the HRS model, as shown in Table 5. Except for the upstream sta (202+70), the water-surface elevations were similar.

### Flow distribution experiments

The distribution of flow between the box culvert and the natural channel was then determined with the type 2 design for discharges of 6,500, 9,100, and 14,600 cfs for existing and future conditions. As mentioned previously, future conditions are those with no overbank flow entering the natural channel. All flow enters from the existing channel and the future bypass channel proposed by SCVWD. Flow distributions with these conditions are shown in Table 6. With a

discharge of 14,600 cfs, 51 percent of the flow was passed through the bypass culvert for existing conditions and 49 percent for future conditions. The desired distribution for this discharge was 55 percent of the flow in the bypass culvert.

### Existing conditions, discharge 14,600 cfs

Water-surface elevations measured with the type 2 design, a discharge of 14,600 cfs, and a tailwater of 77.6 are provided in Table 7. Plots of these elevations for the Guadalupe River (natural channel) are shown as profiles in Plates 13-15. The flow depths measured in the bypass culvert are shown in Table 8 and the water-surface profiles for the bypass culvert with existing conditions and an inflow of 14,600 cfs are shown Plates 16 and 17. No excessive water-surface elevations were observed except at the Santa Clara St. Bridge, where the desired clearance of 1 ft was not achieved at all locations underneath the bridge.

### Future conditions, discharge 14,600 cfs

The water-surface elevations measured for future conditions with the type 2 design, a discharge of 14,600 cfs, and a tailwater el of 77.6 are provided in Table 9. Water-surface profiles for these conditions are shown in Plates 18-20. The flow depths measured in the bypass culvert are listed in Table 10 and the profiles for the bypass culvert with future conditions and an inflow of 14,600 cfs are shown in Plates 21 and 22.

### Weir elevation experiments

Water-surface elevations measured on the upstream face of the weir with a discharge of 1,500 cfs indicated the weir could be lowered 0.75 ft without being overtopped. The weir was lowered from el 79.77 to 79.02 and the flow split was determined for discharges of 6,500, 9,100, and 14,600 cfs for both existing and future conditions. Flow distributions determined from these experiments are provided in Table 11. Comparing the flow distributions with those obtained with the weir at el 79.77 (Tables 6 and 11), more flow was bypassed for the lower discharges and less with a discharge of 14,600 cfs with existing conditions. With future conditions, more flow was bypassed for discharges of 14,600 and 6,500 cfs and the distribution remained the same for a discharge of 9,100 cfs.

Experiments to determine if lowering the ogee weir from el 79.77 to 79.02 affected the water-surface elevations for the design discharge of 14,600 cfs were then performed. An abbreviated set of data was obtained in the river and bypass culvert to compare with the previous measurements. Water-surface elevations measured in the river are shown in Table 12, and depths measured in the bypass are shown in Table 13. A slight reduction in water-surface elevation upstream from the bypass entrance was observed with the lower weir.

## Santa Clara St. Bridge experiments

Experiments were conducted next to determine the backwater effect (measured in the model at sta 151+27) on the water-surface elevations near the Santa Clara St. Bridge. One of the highest water-surface elevations midway underneath the Santa Clara St. Bridge occurred near the right wall at sta 155+50 with a discharge of 14,600 cfs. This location was approximately 420 ft upstream from the station where the river stage was set. The stage at sta 151+27 was lowered in increments of 1 ft and the change in water level under the Santa Clara St. Bridge was recorded. The results shown in Plate 23 indicate the water level drops almost directly with the amount the river stage at sta 151+27 is lowered, which should occur with downstream control. The experiments were also conducted with pier extensions placed on the upstream piers. Results were similar to those without piers except for the condition with a 5-ft lower stage where the flow regime began to change.

Experiments were then conducted to determine if structural modifications would help lower the water level underneath the Santa Clara St. Bridge with a discharge of 14,600 cfs. Pier extensions designed according to guidance in Engineer Manual 1110-2-1601[1] and shown in Plate 24 were placed on the existing piers. Comparing the water-surface elevations measured without pier extensions (Table 14) with the water-surface elevations with pier extensions (Table 15) indicated there were no significant differences. The flow profile with pier extensions is smoother with less wave action and the pier extensions did reduce flow disturbances upstream from the bridge. They also will be beneficial in preventing large debris from accumulating throughout the depth of flow, and for these reasons the pier extensions are desirable at the Santa Clara St. Bridge.

The channel expansion downstream from the Santa Clara St. Bridge was narrowed by installing a wall from the right abutment downstream generally along the east side of the riverwalk as shown in Plate 25. This modification also did not have any significant effect. Water-surface elevations measured without bridge pier extensions with this design are shown in Table 16. The downstream river stage at sta 151+27 was the major influence on the water level at the Santa Clara St. Bridge.

The service road under the Santa Clara St. Bridge was removed to see if this would lower the water levels under the bridge. Water-surface elevations measured without the service road are shown in Table 17. Comparison with water-surface elevations with no modifications (Table 14) shows there is an increase in water level through the bridge, but no increase upstream of the bridge. The water-surface elevations measured at stations under the bridge are higher as a consequence of the flow redistributing due to the change in cross section. The service road was left out of the model until experiments performed at the end of the study.

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[1] U.S. Army Corps of Engineers. (1994). "Hydraulic design of flood control channels," Engineer Manual 1110-2-1601, Washington, DC.

## Sediment experiments with type 2 design

A sediment experiment was conducted with a steady discharge of 14,600 cfs and existing conditions. The sediment analysis conducted for the GDM indicated that during the 100-year-frequency flow event, approximately 10,000 cu yd of bed material may accumulate in the reach from Interstate Highway 280 to Park Avenue. The design flow hydrograph indicates discharges above 14,000 cfs occur for approximately 2.5 hr (prototype). The sediment experiment was performed by introducing the prototype equivalent of 5,000 cu yd of sediment with a model $d_{50}$ size of 0.2 mm in 2.0 hr (prototype) and allowing clear water to discharge for another 0.5 hr. Sediment deposition from this experiment is shown in Photos 19-21. The largest deposits occurred between the Interstate 280 piers adjacent to the overbank flow areas (Photo 19) and upstream from the diversion weir (Photos 20 and 21). The sediment accumulated up to near the crest of the ogee weir, as shown in Photo 20. Sediment also accumulated on the left side of the channel between the bypass and the Woz Way Bridge, in the right box of the bypass culvert, and upstream from the pier at the confluence of the culvert and river channel. The sediment that deposited between the piers and in front of the weir was hardened with cement. The flow distribution between the river channel and bypass culvert for a discharge of 14,600 cfs and existing conditions was then determined with these additional nonerodible areas in the model. Fifty percent of the total inflow was diverted down the bypass culvert. This was slightly higher than observed previously without the nonerodible areas. Another sediment experiment was conducted using a mixture of very small gravel and sand. The sand was more coarse than that used in the first experiment. Approximately 2 ft of the sand and gravel was placed on the bed of the channel between stations 202+00 and 192+00 before beginning the experiment. The sediment (5,000 cu yd) was introduced uniformly over a 2.5-hr (prototype) period and the model was shut off without allowing any clear water flow. This procedure was considered more representative of actual field conditions. Results were similar to the first experiment; however, sediment accumulations were greater. The areas of deposition from this experiment are shown in Plate 26.

## Bridge debris experiments

Debris was placed on the piers of the Woz Way, San Carlos Street, Park Avenue, San Fernando Street, and West Santa Clara Street Bridges to observe the effect on the flow conditions at the bridges. Debris was placed throughout the depth of flow on the existing pier(s) and projected out from each side of the pier approximately 1 ft. The capacity of the bridges was not affected for this debris loading.

## Modifications to the Bypass Entrance and Weir

### Type 2 bypass entrance

Experiments were conducted next to determine if modifying the bypass entrance or weir design would increase the amount of flow into the bypass culvert. The type 2 bypass entrance (Plate 27) consisted of extending the entrance 15 ft upstream and out into the Guadalupe River to intercept and redirect more of the river flow into the bypass culvert. Results from experiments with a discharge of 14,600 cfs for existing and future conditions listed in Table 18 indicated that for existing conditions, 51 percent of the total flow entered the culvert and 52 percent entered the culvert for the future conditions. This was a 2-percent increase for existing conditions and no change for future conditions.

### Type 3 weir and type 2 bypass entrance

Additional modifications were made to try and increase the flow down the bypass culvert with the design flow of 14,600 cfs. Experiments were performed with the type 3 weir and type 2 bypass entrance shown in Plate 28. The type 3 weir replaced the original design ogee weir and consisted of a thin, straight, sharp-crested weir 88.66 ft long with the crest of the weir at el 79.02. This weir was less effective than the ogee with 48 percent (Table 18) of the flow diverted down the bypass for future conditions and a discharge of 14,600 cfs.

### Type 3 bypass entrance and type 3 weir

A vertical wall was extended 50 ft from the type 2 bypass entrance upstream to the highway pier (GR8 bent 21) as shown in Plate 29. This was designated the type 3 bypass entrance and was intended to capture more of the Guadalupe River flow. For future conditions with a discharge of 14,600 cfs, 50 percent of the flow was diverted down the bypass culvert. This was an improvement over the type 3 weir and type 2 bypass entrance, but was still less than the 52 percent measured with the type 2 bypass entrance only and was less than the 55 percent desired. There was concern over sediment deposition and attaching a wall to an existing highway pier, so this approach was not favorable.

### Type 3 bypass entrance, type 3 weir, and type 3 upstream channel

The sediment experiments conducted previously revealed that heavy deposits occurred upstream from the bypass on the right (looking downstream) side of the channel near the highway piers. An experiment was conducted with sandbags placed as shown in Plate 30 to represent a sediment buildup in this area. This modification was designated the type 3 upstream channel. Results (see Table 18) indicated 51 percent of the flow was bypassed for future conditions with the type 3 upstream channel. This was not a significant improvement, so the type 3 upstream channel was removed.

### Type 4 weir, type 2 bypass entrance

Additional experiments were performed with different weir designs. The type 3 weir was replaced with a thin, sharp-crested, semicircular-shaped weir, the type 4 weir shown in Plate 31. The type 4 weir provided more weir length than the previous designs. The type 2 bypass entrance was placed back in the model and a flow distribution experiment was conducted. This design was not effective (see Table 18) in increasing the bypass flow.

### Type 4 weir, original design entrance

The type 2 bypass entrance was removed and experiments were performed with the type 4 weir and the original entrance. The flow distribution was increased, and 51 percent was bypassed with future conditions. This was still less than desired. Results are provided in Table 18 under type 4 weir.

### Type 5 weir

The type 4 weir was replaced with the type 5 weir, which consisted of four semicircular-shaped arcs, as shown in Plate 32. The weir was also a thin sharp-crested type with the crest at el 79.02. This design contained more weir length than the type 4 weir, but was less effective (48 percent bypassed, Table 18).

The experiments with various weir designs indicated the amount of flow bypassed was fairly insensitive to the weir design. The type 5 weir was removed and an experiment was conducted to determine the flow split with no weir. For future conditions, 53 percent of the flow was bypassed down the culvert (see Table 18). This was less than the 55 percent desired.

Experiments were then conducted to determine the height of weir needed in the Guadalupe River downstream from the bypass to divert 55 percent of the total flow. A temporary 4.5-ft-high weir was constructed near sta 194+15 using bricks. The location of this weir is shown in Plate 33. The weir did not extend from bank to bank and was not sealed. Results listed in Table 18 revealed that 54 percent of the flow was bypassed for future conditions. The weir was raised to 8.3 ft high and 55 percent was bypassed for future conditions with a discharge of 14,600 cfs. Results from these experiments and the experiment with no weir indicated that the orientation of the flow in the approach channel to the bypass culvert was probably the major influence on the amount of flow diverted.

### Additional flow comparison experiments

SPK was concerned that the flow distributions determined from the HRS model tests were different than those determined from the WES model. The experimental conditions used in the WES model were slightly different from those conducted in the HRS model, so additional experiments were conducted with the WES model

using the HRS conditions. The HRS experiments were conducted with the river stage at sta 190+00 of the Guadalupe River set at 87.5 with a total inflow of 14,600 cfs. The original ogee weir with a crest el of 79.77 was placed back in the model and the stage at sta 190+00 was set at 87.5. An experiment was conducted for future conditions with a discharge of 14,600 cfs and results provided in Table 18 showed that 52 percent of the flow was bypassed.

Review of slides taken of the HRS model showed there was no entrance pier in the culvert as there was in the WES model. The pier, located as shown in Plate 34, was removed and an experiment was conducted with WES conditions, stage at sta 190+00 at el 86.9. For future conditions with a discharge of 14,600 cfs and the river stage at sta 190+00 at el 86.9, 52 percent of the flow was diverted through the bypass culvert. This was a 3-percent increase over the conditions with the pier in place. An experiment was then conducted with the HRS conditions (river stage at sta 190+00 set at el 87.5) and the pier removed. For future conditions with a discharge of 14,600 cfs, 54 percent of the total flow was diverted through the bypass culvert (see Table 18). This compared reasonably with the HRS results of 55 percent diverted down the bypass culvert and WES and SPK were satisfied that both models reproduced the flows sufficiently.

### Types 4 and 5 upstream channel

Since the flow in the approach channel to the bypass appeared to be the main influence on the amount of flow diverted down the bypass, experiments were conducted with modifications to the channel upstream to try and force more flow through the bypass culvert. The type 4 upstream channel consisted of one layer of bricks placed as shown in Plate 35 along with the original design weir at el 79.77. The weir was kept at el 79.77 for the remaining experiments. This design represented raising the invert of the channel in this area by 4.75 ft. An experiment was conducted for future conditions with a discharge of 14,600 cfs and 52 percent of the flow was diverted through the bypass culvert (see Table 18). The invert was raised another 4.75 ft by adding another layer of bricks, resulting in the type 5 upstream channel shown in Plate 35. Results with this design and future conditions indicated that 55 percent was diverted through the bypass, the amount desired.

### Type 6 upstream channel

Since the type 5 upstream channel provided the desired flow distribution for future conditions, the bricks were replaced with pea gravel and hardened with cement. This was designated the type 6 upstream channel (Plate 35) and results for future conditions (Table 18) also revealed that 55 percent of the flow was diverted down the bypass culvert. An experiment was then conducted with existing conditions and 51 percent of the flow entered the bypass culvert (see Table 18). The type 6 upstream channel was demonstrated for SPK and observations indicated that the type 6 upstream channel could probably be modified to increase the amount of flow diverted through the bypass.

### Types 7 and 8 upstream channel

Since the type 6 upstream channel improved the amount of flow diverted into the bypass channel for existing conditions, temporary modifications were made using bricks and sandbags to observe the effects of reshaping the right bankline between stations 196+50 and 194+00. These temporary modifications were noted as the types 7 and 8 upstream channel shown in Plate 36 and were observed during a visit by SPK personnel. No data were obtained with these temporary modifications and SPK indicated they would furnish a more detailed design incorporating features from the type 8 upstream channel at a later date.

### Type 9 upstream channel and type 4 bypass entrance

The next design furnished by SPK (type 9 upstream channel, Plate 37) consisted of moving the left wall of the original design channel between stations 200+00 and the weir riverward. The length of the ogee weir was reduced by approximately 21 ft and the access ramp moved downstream from the weir (type 4 bypass entrance) as shown in Plate 37 along with the type 9 upstream channel. The original design left wall and ramp are shown in Plate 37 as dashed lines. These changes were required due to seismic upgrades of the highway piers located in the vicinity of the channel. Experiments conducted with this design indicated that for the design flow and future conditions, 36 percent of the flow was diverted down the bypass culvert. This was a significant reduction from the previous designs investigated and was well below the desired diversion of 55 percent.

### Type 10 upstream channel

The right bank (east bank) of the channel was modified between stations 198+50 and 196+00 as shown in Plate 37. This change consisted of moving the bankline out into the channel to try and direct more flow down the bypass culvert. This modification was designated the type 10 upstream channel and included the left wall modifications made for the type 9 upstream channel. A flow diversion experiment with this design indicated 6,850 cfs of the 14,600 cfs (47 percent) was diverted down the bypass culvert with future conditions. Center-line water-surface elevations measured between stations 200+00 and 192+00 with the type 10 upstream channel and type 4 bypass entrance for future conditions are provided in Table 19. These elevations were higher than those measured previously with the type 2 design listed in Table 9.

### Type 11 upstream channel

Modifications were continued to the channel upstream from the bypass entrance to try and increase the diversion flow. The right side of the channel was modified further by moving the right bankline out into the channel between stations 196+00 and 193+50. This change, designated the type 11 upstream channel (shown in Plate 38) included features from the type 8 upstream channel discussed above. Results from a flow diversion experiment indicated 6,900 cfs of the 14,600 cfs (47 percent) was diverted down the bypass culvert with future

conditions and 6,650 cfs (46 percent) with existing conditions. Center-line water-surface elevations measured between stations 200+00 and 192+00 with the type 11 upstream channel and type 4 bypass entrance for both future and existing conditions are provided in Table 20. This modification caused the water-surface elevations to increase upstream from the weir.

### Type 5 bypass entrance

The curvature of the ogee weir was reversed and the diversion point was moved farther out into the Guadalupe River to try and intercept and divert more of the river flow. This design was the type 5 bypass entrance shown in Plate 39. Results of flow diversion experiments conducted with the type 5 bypass entrance and type 11 upstream channel indicated 8,050 cfs (55 percent) was diverted down the bypass culvert with the design flow and future conditions and 7,850 cfs (54 percent) was diverted with existing conditions. Center-line water-surface elevations measured between stations 200+00 and 192+00 with future and existing conditions are provided in Table 21.

### Type 1 pier extensions

Since the flow diversion was approaching the desired distribution, various combinations of pier extensions were placed on the existing piers in the upstream channel with the type 5 bypass entrance and type 11 upstream channel to determine the effect on the flow conditions and water-surface elevations. Pier extensions on all piers between stations 200+00 and 194+00 were designated the type 1 pier extensions. Flow diversion experiments indicated 8,200 cfs (56 percent) was diverted down the bypass culvert with the design flow and future conditions and 8,000 cfs (55 percent) was diverted with existing conditions. Center-line water-surface elevations measured between stations 200+00 and 192+00 with future and existing conditions are provided in Table 21. A comparison of the center-line water-surface elevations with and without the pier extensions for future and existing conditions and the design discharge are shown in Plate 40. The type 1 pier extensions had minor effects on the center-line water-surface elevations and practically no change was observed downstream from station 198+00. The pier extensions did improve the flow conditions in the channel upstream from the weir by reducing the localized flow disturbances around each of the piers.

### Type 2 pier extensions

The pier extensions were removed from the four piers between stations 198+00 and 195+00, resulting in the type 2 pier extensions. Experiments with the design discharge and future conditions indicated 55 percent of the flow, 8,050 cfs, was diverted down the bypass. Center-line water-surface elevations are provided in Table 21, and water-surface profiles measured with the types 1 and 2 pier extensions are compared in Plate 41. No significant differences in water-surface elevations between the types 1 and 2 pier extensions were observed.

### Type 3 pier extensions

Pier extensions were then placed on piers located between stations 198+00 and 195+00 only, resulting in the type 3 pier extensions. Experiments with the design discharge and future conditions indicated 52 percent of the flow, 7,600 cfs, was diverted down the bypass. Center-line water-surface elevations for future conditions are shown in Table 21 and a comparison with the types 1 and 2 pier extensions shown in Plate 41 indicates no significant change.

### Type 4 pier extensions

Pier extensions were then placed on all piers located between stations 200+00 and 194+00 except the three between stations 197+00 and 195+00, resulting in the type 4 pier extensions. Experiments conducted with the type 11 upstream channel, type 5 bypass entrance, and type 4 pier extensions for the design discharge and future conditions indicated 55 percent of the flow, 8,050 cfs, was diverted down the bypass. Center-line water-surface elevations are shown in Table 21, and with the types 1-3 pier extensions in Plate 41. Water-surface elevations measured were lower with the type 4 pier extensions than the previous designs investigated for the design flow and future conditions.

### Type 12 upstream channel

The right bank between stations 196+00 and 194+00 was modified by removing a portion at the toe of the bank, as shown in Plate 42. This modification was made to widen the channel in an effort to lower the upstream water surface. Experiments conducted with the type 12 upstream channel, type 5 bypass entrance, and type 1 pier extensions indicated that 53 percent ( 7,700 cfs) of the flow was diverted down the bypass culvert with the design flow and future conditions. Center-line water surface elevations are provided in Table 22, and no significant lowering was observed with this modification.

### Type 13 upstream channel

The left channel wall was modified by moving the beginning of the wall downstream to sta 198+60 and tying back into the existing wall around sta 197+70, as shown in Plate 43. This modification was also made in an effort to lower the upstream water surface. Experiments conducted with the type 13 upstream channel, type 5 bypass entrance, and type 1 pier extensions indicated that 54 percent ( 7,850 cfs) of the flow was diverted down the bypass with the design flow and future conditions and that 51 percent ( 7,450 cfs) was diverted with existing conditions. Center-line water-surface elevations measured with this design and existing conditions are provided in Table 23 and compared with the type 11 upstream channel water-surface elevations in Plate 44. Water-surface elevations measured with the type 13 upstream channel were lower than the type 11 upstream channel between stations 200+00 and 195+50, but were higher between stations 195+00 and 192+00.

### Type 14 upstream channel and type 5 pier extensions

The left wall was modified between stations 199+50 and 197+00 and the right side of the channel was modified between stations 200+50 and 197+00, type 14 upstream channel, as shown in Plate 45. Sloping pier extensions were placed on all piers between stations 200+00 and 194+00 and the proposed 9-ft-diam caltrans seismic retrofit outrigger column at GR1 Line Bent 4 was added. The pier extension modifications were designated the type 5 pier extensions. Experiments conducted with the type 14 upstream channel, type 5 bypass entrance, and type 5 pier extensions indicated 54 percent (7,850 cfs) of the flow was diverted down the bypass with the design flow for both future and existing conditions. Center-line water-surface elevations measured with this design for future and existing conditions are provided in Table 24 and plotted in Plate 46. No significant lowering of the water-surface elevations in the upstream channel was observed between the types 13 and 14 design upstream channels for existing conditions.

### Type 15 upstream channel

The left wall of the channel between stations 199+50 and 195+50 was moved farther to the left to widen the channel and determine the effects on the water-surface elevations. This change was the type 15 upstream channel shown in Plate 47. Experiments conducted with the type 15 upstream channel, type 5 bypass entrance, and type 5 pier extensions indicated that 55 percent ( 8,100 cfs) of the flow was diverted down the bypass with the design flow and future conditions. Center-line water-surface elevations measured with these designs for future conditions are listed in Table 25 and compared with the type 14 upstream channel in Plate 48. Water-surface elevations measured with the type 15 upstream channel and future conditions were lower between stations 200+ 50 and 199+00 and slightly higher between 198+00 and 196+00 compared to those measured with the type 14 upstream channel. The lower upstream water surface was desirable.

### Type 16 upstream channel

A temporary modification was made to the diversion and weir as shown in Plate 49. The right entrance wall at the diversion was extended 12.5 ft upstream and the area between the wall and the weir was filled with brick. No data were obtained with this temporary modification, but observation of the flows indicated the wall extension improved the concentrated flow conditions in the Guadalupe River downstream from the diversion.

### Type 17 upstream channel and type 6 bypass entrance

A more permanent modification was made to the diversion wall and entrance and the bricks were removed between the extended wall and the ogee weir to form the type 17 upstream channel and type 6 bypass entrance shown in Plate 50. Experiments conducted with the type 17 upstream channel, type 6 bypass

entrance, and type 5 pier extensions indicated that 57 percent ( 8,270 cfs) of the flow was diverted down the bypass with the design flow and future conditions and that 55 percent (8,040 cfs) was diverted with existing conditions. Center-line water-surface elevations measured with these designs for future and existing conditions are provided in Table 26 and compared with the types 14 and 15 upstream channel in Plate 51. Again, no significant differences were observed between the water surface with the types 14, 15, and 17 upstream channel designs.

### Type 18 upstream channel, type 7 bypass entrance, and type 6 pier extensions

The left side of the channel had to be modified again between stations 199+50 and the ogee weir due to seismic concerns, and the right side was modified again between stations 200+50 and 194+00 to accommodate a pier located on the top bank near sta 199+00 and for architectural reasons. These modifications were designated the type 18 upstream channel. The geometry near the diversion wall was modified to form the type 7 bypass entrance and pier extensions were removed from the three piers between 197+00 and 195+00, type 6 pier extensions. These modifications are shown in Plate 52. Experiments conducted with the type 18 upstream channel, type 7 bypass entrance, and type 6 pier extensions indicated that 55 percent ( 8,100 cfs) of the flow was diverted down the bypass culvert with the design flow for both future and existing conditions. Center-line water-surface elevations measured with these designs for future and existing conditions are listed in Table 27 and compared with the types 17 and 15 upstream channel water-surface elevations in Plate 53. The center-line water-surface elevations were lower between stations 199+00 and 195+00 with the type 18 upstream channel, the type 7 bypass entrance, and type 6 pier extensions.

### Type 8 bypass entrance

Flow distribution between the right and left sides of the bypass culvert was not equal with the type 18 upstream channel, type 7 bypass entrance, and type 6 pier extensions. Of the 8,100 cfs diverted down the bypass culvert, 3,800 cfs entered the left side of the culvert and 4,300 cfs entered the right side. Experiments were performed with the type 8 bypass entrance shown in Plate 54 to determine if this modification would distribute the flow better. The type 8 bypass entrance consisted of placing a 1-ft-thick, 17-ft-high curved wall extension from the start of the existing divider wall to a location 13.5 ft downstream from the toe of the existing weir spillway. Experiments conducted with the type 18 upstream channel, type 8 bypass entrance, and type 6 pier extensions indicated that 55 percent ( 8,070 cfs) of the flow was diverted down the bypass with the design flow for future conditions and of this amount, 4,040 cfs entered the left side and 4,030 entered the right side. Center-line water-surface elevations measured with these designs for future conditions are listed in Table 28 and compared with the type 7 bypass entrance water-surface elevations in Plate 55. There was a slight increase in upstream water surface with this design and also flow bulked up at the

beginning (upstream end) of the wall extension. Water-surface profiles along the right and left sides of the wall extension are shown in Plate 56 and the water-surface elevations measured for these profiles are provided in Table 29.

### Type 9 bypass entrance

Experiments with the type 9 bypass entrance shown in Plate 54 were performed next to try and reduce the flow disturbances at the upstream end of the wall. The type 9 bypass entrance consisted of the 1-ft-thick, 17-ft-high curved wall extension from the start of the existing divider wall to a location 13.5 ft downstream from the toe of the existing weir spillway with a 1V on 1H slope at the upstream end. Experiments conducted with the type 18 upstream channel, type 9 bypass entrance, and type 6 pier extensions indicated 55 percent (8,040 cfs) of the flow was diverted down the bypass with the design flow for future conditions and of this amount, 3,980 cfs entered the left side and 4,060 cfs entered the right side. Center-line water-surface elevations were measured with these designs for future conditions and are listed in Table 28 and compared with the types 7 and 8 bypass entrance water-surface elevations in Plate 55. There was a slight reduction in upstream water surface with this design and the flow conditions at the upstream end of the wall were improved from the type 8 bypass entrance. Water-surface profiles along the right and left sides of the wall extension are shown in Plate 57 and the water-surface elevations measured for these profiles are provided in Table 30.

### Type 10 bypass entrance

Experiments were then conducted in an attempt to try and evenly distribute the flow entering the bypass culvert by modifying the upstream end of the existing divider wall. The type 10 bypass entrance shown in Plate 58 consisted of widening the upstream end of the divider pier from 4 ft to 5.5 ft. This modification had no significant impact on the flow distribution from that determined with the type 7 bypass entrance. Experiments conducted with the type 18 upstream channel, type 10 bypass entrance, and type 6 pier extensions indicated 55 percent (8,000 cfs) of the flow was diverted down the bypass with the design flow for future conditions and of this amount, 3,760 cfs entered the left side and 4,240 entered the right side. Center-line water-surface elevations between stations 200+50 and 192+00 are listed in Table 31 along with the type 7 bypass entrance water-surface elevations for comparison. There was no significant difference between the water-surface elevations measured for the types 7 and 10 bypass entrance designs.

### Types 11-13 bypass entrance

Experiments were conducted next to determine if changing the alignment of the upstream end of the existing divider wall would affect the distribution of flow entering the right and left sides of the bypass culvert. The upstream end of the original 4-ft-wide divider pier was moved to the right, as shown in Plates 59-61. These modifications were designated the types 11, 12, and 13 bypass entrances.

The flow distribution for these designs is provided in Table 32. The type 13 bypass entrance, with the upstream end of the divider wall moved approximately 6.3 ft to the right, provided the best distribution of the three designs examined. The water-surface differential at the divider wall between the right and left sides of the culvert increased over those observed with the type 9 bypass entrance for the types 11-13 bypass entrance designs. This increase was not desirable and therefore the type 9 bypass entrance was placed back in the model. The upstream water surface was not significantly affected by the types 11-13 bypass entrance designs. A partial summary of the flow distributions measured with the modifications discussed above is provided in Table 33.

## Type 6 pier extensions, type 9 bypass entrance, type 18 upstream channel

The previous experiments with the type 6 pier extensions, type 9 bypass entrance, and type 18 upstream channel indicated these modifications provided acceptable flow conditions in the upstream channel and the desired flow diversion.

### Discharge 14,600 cfs

The water-surface elevations measured in the Guadalupe River with the type 6 pier extensions, type 9 bypass entrance, and type 18 upstream channel with an inflow of 14,600 cfs and future conditions are provided in Table 34. The water-surface profiles in the river are included in Plates 62-64. Water-surface measurements obtained in the box culvert are provided in Table 35 and profiles in the culvert are shown in Plates 65 and 66.

### Discharge 9,100 cfs

Additional water-surface measurements were made for a discharge of 9,100 cfs with future conditions. Measurements obtained with a discharge of 9,100 cfs are listed in Table 36. The type 11 bypass entrance was in place for the experiments with a discharge of 9,100 cfs, although no change in river water surface was observed since the flow distribution between the river and the bypass culvert was similar between the types 9 and 11 bypass entrances. Water-surface profiles of the river with a discharge of 9,100 cfs are shown in Plates 67-69. Water-surface measurements in the culvert are provided in Table 37, and the profiles are shown in Plates 70 and 71.

### Discharge 6,500 cfs

Water-surface elevations obtained with a discharge of 6,500 cfs and future conditions are provided in Table 38. The type 9 bypass entrance was in place for these experiments. River profiles are shown in Plates 72-74. Table 39 lists the water depths measured in the culvert with a discharge of 6,500 cfs and the culvert profiles are provided in Plates 75 and 76.

Flow distributions measured with discharges of 14,600, 9,100, and 6,500 cfs and various modifications are shown in Table 40. The desired flow split (55 percent of the total inflow down the bypass culvert) was achieved with 14,600 cfs and future conditions. The flow distribution to the bypass culvert with a discharge of 9,100 cfs was 55 percent for both future and existing conditions. The flow distribution with a discharge of 6,500 cfs was 48 percent with future conditions and 50 percent with existing conditions.

### Velocity measurements near the piers

Experiments were performed to obtain velocity measurements in the vicinity of selected piers within the channel. These measurements were made to help evaluate the flow distribution in the channel and determine the type scour protection material required. Velocity measurement locations are provided in plan view drawings of the pertinent portion of the channel and the magnitudes are provided in tables. The velocities are averaged over a specified time period (generally 10 sec in the model) and the measurements indicate the magnitude of the dominant streamwise component at 1 ft and 3 ft off the invert. The stations designated with a numeric value followed by the letter "a" represent the measurement made 3 ft off the invert.

### Velocity measurements near GR1 bent 2 and GR1 bent 3

The velocity locations for piers GR1 bent 2 and GR1 bent 3 are shown in Plate 77 and magnitudes are provided in Tables 41 and 42, respectively. Near pier GR1 bent 2, velocities ranged from 1.4 to 7.9 ft/sec and near pier GR1 bent 3, velocities ranging from 1.0 to 13.9 ft/sec were measured. The lower velocities usually indicate measurements made in the wake of the pier.

### Velocity measurements near GR1 bent 4

The locations of the velocity measurements near GR1 bent 4 are shown in Plate 78 and the magnitudes are listed in Table 43. In later experiments, a 10-ft-diam new pier was placed adjacent to GR1 bent 4. Velocities measured near GR1 bent 4 ranged from 0.8 to 13.9 ft/sec.

### Velocity measurements near D bent 15-D, 15-C, 15-B, and 15-A

The plan view locations for velocity measurements made near piers D bent 15-D, C, B, and A are shown in Plate 79. Magnitudes of the measurements are provided in Tables 44-47, respectively. A temporary pier extension was in place during the measurements made near D bent 15-D. Velocities near 14 ft/sec were measured near the invert adjacent to the proposed gabion steps on the right side of the channel between stations 197+50 and 196+50. The highest velocity measured was at station 1a of D bent 15-C and was 16.9 ft/sec. The range of velocities measured near these piers indicates a rapidly varying flow field with wakes, concentrated flows, and highly three-dimensional flow conditions.

## Velocity measurements near GR5 bent 15 and GD3 bent 7

Measurement locations for GR5 bent 15 and GD3 bent 7 are shown in Plate 80 and the magnitudes of the velocity measurements are listed in Tables 48 and 49. These measurements were also made with temporary pier extensions in place. Velocities near the center of the channel were around 10 ft/sec.

## Type 7 pier extensions

The need for pier extensions on some of the existing piers had been partially evaluated previously using temporary pier extensions quickly fabricated from sheet metal and wood. An improvement in flow conditions was observed when these pier extensions were used on piers GR1 bent 4, the new 10-ft-diam pier on the right side of pier GR1 bent 4, GR5 bent 15, GD3 bent 7, D bent 15-D, GR8 bent 21, and GD4 bent 12. The temporary pier extensions on these particular piers were the type 6 pier extensions described previously. The temporary pier extensions were replaced with more permanent sloping pier extensions, type 7 pier extensions, designed from guidance presented in EM 1110-2-1601.[1] The pier extension design used is shown in Plate 81. Some of the pier extension details are provided in Table 50. The variable W, the pier width, depends on the particular pier and its orientation with the flow. The variable R is the radius at the upstream end or nose of the pier extension. R was 1 ft for all piers less than 10 ft wide. The height of the piers was determined based on the maximum water-surface elevations measured with the design flow of 14,600 cfs and future conditions. The depth of flow ranged from about 14 to 15.5 ft, so 16 ft was chosen as the pier height. The remaining dimensions were based on criteria given in EM 1110-2-1601.[1]

The pier extensions improved the flow conditions around the piers by reducing the flow concentrations and providing a more streamlined approach and exit. Alignment of the pier extensions for the piers between stations 201+00 and 194+00 is shown in Plate 82. The angle for the azimuth of the pier extension center line gives the orientation of the pier. The azimuth refers to grid north taken from coordinates given on SPK drawings labeled "Pier Locations," sheets 9 and 10. This alignment should be modified as necessary if the alignment of the channel to be constructed changes and does not match the alignment used in the model. The alignment of piers GVC bent 5A and GRV bent 3B is shown in Plate 83. Flow conditions near these piers were improved in the same manner observed with the upstream piers. The water surface was smoothed and the wake disturbances were not as severe.

Pier extensions for the Guadalupe River bridges were also evaluated. Results of the experiments performed with pier extensions for the Santa Clara St. Bridge were described in previous paragraphs (see Plate 24). These results indicated there were no significant changes in the water-surface elevations under the bridge with the pier extensions. The pier extensions do reduce flow disturbances at the upstream side

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[1] U.S. Army Corps of Engineers. (1994). "Hydraulic design of flood control channel," Engineer Manual 1110-2-1601, Washington, DC.

of the bridge, which reduces the wave action through the bridge and is more hydraulically desirable. The reduction in flow disturbances indicates less turbulence in the flow and will probably tend to reduce the localized scour. The sloping portion of the pier extension, also referred to as a debris nose, is considered beneficial in preventing debris from accumulating at the bridge.

Experiments were performed at the San Fernando St. Bridge with the same design pier extension used on the Santa Clara St. Bridge. Water-surface profiles measured along the pier without a pier extension for a discharge of 14,600 cfs are shown in Plate 84. Water-surface profiles measured along the pier with a pier extension for a discharge of 14,600 cfs are shown in Plate 85. There was no significant reduction in the water-surface elevation, but again the pier extensions are considered beneficial for debris purposes and reducing turbulence.

Observations of the flows at the remaining bridges, Park Avenue, San Carlos, and Woz Way, revealed these bridges would not benefit significantly from pier extensions. Adequate clearance was present at all three bridges. The alignment of the pier and flow at San Carlos would not be desirable for a pier extension placed in line with the existing pier.

### Type 7 pier extensions, type 14 bypass entrance, type 18 upstream channel

The right side of the ogee weir at the bypass entrance was rotated as shown in Plate 86. The upstream end of the divider wall was maintained at a distance 13.5 ft downstream from the downstream toe of the weir, which meant the overall length of the divider wall increased by 9.6 ft (along the center line of the divider wall). These modifications were designated the type 14 bypass entrance. A flow distribution experiment was performed with these designs and the results indicated 55 percent of the flow was diverted down the bypass for a discharge of 14,600 cfs and future conditions (Table 40). This was similar to the previous experiments with the type 6 pier extensions, type 9 bypass entrance, and type 18 upstream channel. Water-surface elevations measured with these designs are listed in Table 51.

### Debris experiments

Qualitative debris experiments were performed using small brushes and wooden dowels of varying lengths, which represented debris 1 ft in diameter. The experiments were conducted with and without pier extensions for a discharge of 14,600 cfs. The results were videotaped and forwarded to SPK for review. Debris accumulation on the piers without pier extensions generally occurred throughout the depth. Debris accumulation on the piers with the pier extensions was observed at the water surface. The heaviest accumulations occurred at the San Fernando St. and Santa Clara St. Bridges and at piers GVC bent 5A and GRV bent 3B without pier extensions.

## Additional sediment experiment

An additional sediment experiment was performed to qualitatively evaluate areas subject to deposition. A mixture of coarse sand and very small gravel was used for the sediment. Before the start of the experiment, approximately 1.5 ft of sediment was placed on the invert of the channel between stations 201+00 and 190+00 to represent bed material. Approximately 5,200 cu yd of sediment were introduced between stations 203+00 and 202+00 over a 2.5-hr period (prototype) with a discharge of 14,600 cfs. The model was then drained and a video was made of the results. Sediment deposition occurred immediately downstream from the point of introduction between stations 201+00 and 199+00. Sediment deposits were also observed on the right side of the channel between stations 199+00 and 198+00. The largest deposit occurred downstream from the confluence between stations 194+00 and 191+85. Center-line and right-and left-side bed profiles of sediment deposition in this area are shown in Plate 87.

The sediment deposits upstream from the ogee weir and between sta 194+00 and 191+85 were hardened with a cement mixture. This was done to determine if the flow distribution was affected by the sediment. For future conditions with a discharge of 14,600 cfs and the type 14 bypass entrance, type 18 upstream channel and no pier extensions, 54 percent of the total inflow was diverted down the bypass culvert. With the conditions above and the type 7 pier extensions, 55 percent of the total inflow was diverted down the bypass culvert. Results from these experiments are provided in Table 52. During a visit to WES in December 1995, SPK requested an experiment to determine the flow distribution with the water-surface elevation at Woz Way (sta 189+50) raised 2 ft. The experiment was conducted with the type 7 pier extensions, type 14 bypass entrance, and the type 18 upstream channel for future conditions with a discharge of 14,600 cfs. With these conditions, 61 percent of the flow was diverted down the bypass. Results are listed in Table 52.

## Type 15 bypass entrance

During the December 1995 visit, SPK also requested that a short deflector wall be placed at the bypass entrance to direct the high-velocity flow away from the left side of the channel immediately downstream from the bypass. This modification was noted as the type 15 bypass entrance and is shown in Plate 88. The flow conditions were videotaped and forwarded to SPK for review. The deflector did direct the flow away from the gabions and also helped spread the flow better in the river channel downstream from the bypass entrance.

## Downstream wall modifications

Earlier in the model investigation, a wall modification was made to the left channel wall just upstream from the Santa Clara St. Bridge, which reduced the width of the channel. This modification produced unacceptable standing waves in the channel. The wall from this modification was realigned to increase the channel

width from the previous modification and details of this modification are shown in Plate 89. This wall did not adversely affect flow conditions in this area.

### Fountain design

A water fountain was proposed for the confluence area and there was concern that some of the walls to be placed in the channel might adversely affect the flow conditions near the confluence. The structural walls of the proposed fountain were placed in the model as shown in a plan view in Plate 90. No adverse impacts to the flow conditions in this area were observed in the model experiments with a discharge of 14,600 cfs.

### Other channel modifications

Minor modifications were made to the river channel for better access to the invert. The left bank under the Park Ave. Bridge was modified slightly and an access ramp to the invert was placed downstream from Park Ave. on the left bank near the confluence. The access ramp upstream from the San Fernando St. Bridge on the right bank was moved downstream to a location just upstream from the bridge. These modifications were in place for the experiments conducted with the types 14 and 15 bypass entrances. The modifications had no significant impacts on the flow conditions in the river channel. However, the access ramp upstream from the San Fernando St. Bridge should not be modified in the future without further evaluation.

### Modified channel and pier alignments

Model details of the upstream channel and pier locations and alignments furnished to SPK for review indicated there were some discrepancies in the geometrics. These discrepancies were not considered major; however, there was concern that the flow distribution and the water-surface elevations in the upstream channel might change. The model was modified to match the SPK drawing received 2 August 1996 and additional experiments were performed. The new pier locations are compared to the old locations in Plate 91.

### Type 19 upstream channel, type 16 bypass entrance, type 8 pier extensions

The right side of the upstream channel was modified between stations 199+50 and 193+00. The curvature of the roadway and the gabion steps to the invert were changed so the gabions would not intersect Pier GR4 bent 2. This modification was designated the type 19 upstream channel and slightly increased the cross-sectional area of the channel near sta 194+00. The SPK drawing also indicated the 4-ft-thick divider wall downstream from the weir in the bypass culvert needed to be moved to the right by 1.5 ft. The 1-ft-thick divider wall upstream from the 4-ft-thick wall was left in its previous position since it was still attached to the thicker wall at the upstream end. The slight misalignment between the walls was not significant. The realignment of the 4-ft-thick wall was designated the type 16

bypass entrance and is shown in Plates 92 and 93. The type 19 upstream channel and the type 16 bypass entrance are shown in Plate 92. Since the pier locations were changed slightly from the type 7 pier extensions, the new piers were designated the type 8 pier extensions and are shown in Plates 91 and 92. The locations of the piers and the alignments of the type 8 pier extensions are provided in Plate 92.

Experiments were performed with the type 16 bypass entrance and type 19 upstream channel for the design flow of 14,600 cfs with future and existing conditions and with and without the type 8 pier extensions. Water-surface profiles measured in the upstream channel between sta 192+00 and 200+50 are shown in Table 53. Comparison of the measurements obtained with and without the type 8 pier extensions for future conditions to the water-surface elevations in Table 51 indicates water-surface elevations upstream from sta 198+50 are similar and water-surface elevations downstream from sta 195+00 are lower with the additional modifications. The water-surface elevations between these stations is generally slightly higher than the comparable elevations in Table 51.

Flow distributions between the bypass culvert and the Guadalupe River for the type 16 bypass entrance, type 19 upstream channel, and the type 8 pier extensions with the design flow are listed in Table 54. Slightly more flow was diverted down the bypass culvert with the new pier locations and modified channel than with previous designs tested. The percentages of the design flow diverted down the bypass culvert for future conditions without pier extensions was 59 percent, and with the type 8 pier extensions was 58 percent. The amount diverted for existing conditions without pier extensions was 55 percent, and with pier extensions was 56 percent.

Photographs of the flow conditions in the channel were obtained with the type 19 upstream, type 16 bypass entrance, and the type 8 pier extensions with a discharge of 14,600 cfs and future conditions. These flow conditions are shown in Photos 22-30 beginning near sta 199+00. Photo 22 shows the flow conditions in the upstream channel between sta 199+00 and the entrance to the bypass culvert. The flow was fairly well distributed throughout the channel down to sta 196+50. At sta 196+00, an eddy formed near the top of the right bank due to flow separation just upstream. A closeup of the flow conditions in the vicinity of the bypass is shown in Photo 23. A large eddy formed at the top of the right bank beginning near sta 194+00 and terminated just downstream from sta 191+00. An eddy also formed at the top of the left bank near sta 193+00 and also terminated downstream from sta 191+00. The flow conditions in the channel near Woz Way Bridge are shown in Photo 24. Flow under the bridge was concentrated in the center of the channel and eddies occurred at the top bank. The flow began to redistribute throughout the channel near sta 188+00. Flow conditions in the Guadalupe River between stations 185+00 and 180+00 near Auzerais Point are shown in Photo 25. The roughness elements used to represent trees near the top bank can be seen in the photo. The trees slow the flow near the top bank and tend to concentrate the flow in the middle of the channel. Photo 26 shows flow in the channel upstream and downstream from the San Carlos St. Bridge. The bridge piers are not aligned with

the streamline approaching the bridge, but adverse flow conditions did not result. Flow conditions between the San Carlos St. Bridge and the Park Ave. Bridge are shown in Photo 27. Most of the flow is toward the left half (looking downstream) of the channel approaching the bridge and an eddy formed at the top right bank under the bridge. Photo 28 shows the flow conditions in the channel downstream of the Park Ave. Bridge and in the vicinity of the confluence. The higher velocity flow was observed along the left wall downstream from the confluence and a significant flow disturbance was caused by the pier at GVC bent 5A. Flow conditions under and downstream from the San Fernando St. Bridge are shown in Photo 29 and flow conditions upstream and downstream of the Santa Clara St. Bridge are shown in Photo 30. Eddies formed along the top right bank due to the scallops along the bank line.

Water-surface elevations in the bypass culvert and in the Guadalupe River downstream from the bypass entrance for existing conditions with the type 16 bypass entrance, the type 19 upstream channel, and with and without the type 8 pier extensions would be similar to those shown in Tables 34 and 35 since the discharges in the bypass culvert and Guadalupe River are similar. Water-surface elevations in the bypass culvert and in the Guadalupe River downstream from the bypass entrance for future conditions with the type 16 bypass entrance, the type 19 upstream channel, and with and without the type 8 pier extensions would be slightly less in the river and slightly higher in the box culvert than those shown in Tables 34 and 35, since the discharge in the bypass culvert was slightly higher. Profiles were not obtained for these conditions due to time constraints; however, the bypass culvert was in no danger of pressurizing with the slightly higher discharges observed with future conditions. With more flow down the box, the design is less resilient to changes in the prototype such as sediment deposits, debris, and increased TW, which could cause increased flows in the box culvert. The box would also pressurize sooner for floods greater than the 1-percent exceedance event.

### Type 17 bypass entrance

SPK requested an experiment to determine the effect of moving the right wall in the bypass culvert out into the culvert an additional 2 ft, as shown in Plate 93 (type 17 bypass entrance). Water-surface elevations in the upstream channel and the flow distribution between the bypass culvert and the Guadalupe River were determined for existing conditions with the design discharge and are listed in Tables 55 and 56, respectively. The flow distribution did not change from the previous design and the water-surface elevations did not change significantly. The restriction in the right box of the culvert caused the flow to go supercritical just downstream from the restriction and a water-surface differential of 5.5 ft was measured on the splitter wall between the right and left boxes approximately 24 ft downstream from the beginning of the splitter wall (the 1-ft-thick wall starting at the downstream end of the divider wall). An oblique jump formed in the right box as the flow returned to subcritical. This flow condition was not desirable due to the hydraulic jump in the right box of the culvert, and for this reason the type 17 bypass entrance was not desired.

### Type 18 bypass entrance

After discussions with SPK about the position of the 4-ft-thick divider wall, it was moved back to its previous position (1.5 ft towards the left side of the bypass entrance). This position was similar to the type 15 bypass entrance, although this design was designated the type 18 bypass entrance (Plate 94) because the upstream channel had been modified since experiments were conducted with the type 15 bypass entrance. Experiments were conducted with the type 18 bypass entrance and type 19 upstream channel to determine the flow distribution between the river and bypass culvert with a discharge of 14,600 cfs, and existing conditions. Results listed in Table 54 revealed that 8,080 cfs, or 55 percent of the total flow, was diverted down the bypass culvert. This was the amount desired.

### Type 19 bypass entrance

There was concern over the alignment of the left wall of the bypass culvert due to coordinate discrepancies that surfaced during the model investigation. The left wall of the bypass culvert was modified as shown in Plate 95 to match information furnished by SPK concerning the distances from the center divider wall to the left culvert wall. This modification was made to ensure that the cross-sectional area of the culvert was correct. The modification to the right side of the bypass culvert, type 17 bypass entrance, was also in place in the model. These modifications were noted as the type 19 bypass entrance and experiments were conducted to determine the distribution of flow between the river and the bypass culvert for existing conditions with a discharge of 14,600 cfs. Results provided in Table 54 indicated that 7,800 cfs, or 53 percent of the flow, was diverted down the bypass culvert. This was less than the 55 percent desired.

### Type 20 bypass entrance

The modification on the right side of the channel was removed and the left wall modification was left in place. This was designated the type 20 bypass entrance shown in Plate 96 and experiments were conducted with future and existing conditions. With future conditions and a discharge of 14,600 cfs, 8,320 cfs (or 57 percent) was diverted down the bypass culvert. With existing conditions and a discharge of 14,600 cfs, 7,920 cfs (or 54 percent) was diverted down the bypass culvert. These flow distributions are listed in Table 54.

### Bridge soffitt at GR5 line

SPK indicated that the bridge soffitt at the GR5 line in the upstream channel was low enough that it could cause the bridge to pressurize. The soffit was installed in the model with the right bank soffit elevations at 90.5 upstream and 90.9 downstream. On the left side of the channel, the soffit elevations were 94.5 upstream and 94.9 downstream. Water-surface elevations were measured in the upstream channel with the type 20 bypass entrance, type 19 upstream channel, and the bridge at the GR5 line. A plan view of the bridge location is shown in Plate 97 and the water-surface elevations in the upstream channel are provided in

Table 56. With existing conditions, the flow impacted the bridge from the right bank out into the channel for 40 ft on the upstream side of the bridge, and the maximum water-surface elevation which occurred at the left bank was 92.2. The right bank water-surface elevation was 91.5. With future conditions, the flow impacted the bridge in an area on the upstream side of the bridge approximately 13.8 ft from the right bank and the maximum water-surface elevation, which also occurred at the left wall, was 91.5. Additional measurements were made between the weir and the bypass culvert entrance to determine the water-surface elevations along the walls at the entrance. Locations of these measurements are shown in Plate 98 and the water-surface elevations at these locations are provided in Table 57.

### Additional experiments at Santa Clara St. Bridge

Additional experiments were requested by SPK to determine the effect of an increased tailwater at the Santa Clara St. Bridge. Before these experiments were performed, the service road under the bridge on the right wall (which had been removed for previous experiments) was placed back in the model. Water-surface elevations which were measured with a discharge of 14,600 cfs and a tailwater elevation of 77.25, are provided in Table 58. The flow impacted the bridge support beams in several locations, and water-surface elevations under the bridge ranged from 74.0 to 79.1. The bridge deck, which was removed to measure water-surface elevations under the bridge, was placed back on to determine if the water surfaces at the San Fernando St. Bridge were raised due to flow impacting the deck at the Santa Clara St. Bridge. Water-surface elevations which were measured at stations 163+00 and 157+00 with a discharge of 14,600 cfs and tailwater elevations of 77.0 and 77.25, are shown in Table 59. The bridge deck at the Santa Clara St. Bridge did not impact the water-surface elevation at the San Fernando St. Bridge, with a discharge of 14,600 cfs and tailwater elevations of 77.0 and 77.25.

### Overbank water-surface elevations

SPK requested that an experiment be performed to determine the water-surface elevations in the overbank areas with existing conditions, the type 19 upstream channel, type 20 bypass entrance, and a total discharge of 14,6000 cfs. The distribution of flow was 9,100 cfs entering from the existing channel, 3,500 cfs from the left overbank, and 2,000 cfs entering from the right overbank. The locations for these water-surface measurements are shown in Plate 99 and the elevations are listed in Table 60. All water-surface elevations were between 92.1 and 92.3. Water-surface elevations in the center of the channel between the overbank areas (sta 198+50 to 195+50) ranged from 88.5 at sta 196+00 to 91.6 at sta 198+50.

Another experiment was performed with future conditions to determine the discharge where flow began entering the overbank areas. Discharges greater than 14,600 cfs caused flow to enter the overbank areas with future conditions.

### Recommended design

The design recommended for the Guadalupe Model consisted of the type 19 upstream channel, type 20 bypass entrance, the left wall modification upstream from Santa Clara, and the modifications to the river channel discussed in the section titled "Other Channel Modifications" above. Before the final changes were made to the model, velocities were measured at desired locations throughout the river channel to determine flow distributions and evaluate scour protection requirements in the river channel. These velocities are shown in Plates 100-104 and were obtained with the type 19 upstream channel, type 16 bypass entrance, and type B pier extensions. These velocities are representative of the recommended design since the discharges in the river and bypass culvert were similar. The magnitudes shown in these plates represent an average velocity of the dominant streamwise (upstream-downstream) component. There are many areas shown in Plates 100-104 in the channel where velocities greater than 10 ft/sec were measured near the invert or channel sides. These areas should be adequately protected to prevent excessive scour. All areas in the natural channel shown in Plates 100-104 with velocities greater than 4 ft/sec should be evaluated for scour protection. The geometry of the channel in many places, especially upstream from the bypass entrance and also immediately downstream from the bypass in the river channel, lends itself to flow concentrations and eddies (swirling flow). While these are not necessarily desirable and efficient hydraulic features, the stability of the channel can be maintained with adequate scour protection. All modifications are summarized in Table 61.

# 4 Summary and Recommendations

Numerous experiments were conducted to evaluate the flow conditions in the Guadalupe River and bypass culverts. The ultimate goal was to develop the desired flow split for the design discharge of 14,600 cfs while maintaining acceptable water-surface elevations in the upstream channel. The desired flow distribution was 55 percent of the flow down the bypass culvert with a total inflow of 14,600 cfs. This goal was achieved with many of the designs. Many of the channel modifications were required due to seismic constraints and aesthetics. The final design will provide acceptable performance as long as the areas exposed to the high velocities are adequately protected.

Pier extensions on the I-280 piers upstream and downstream from the bypass culvert were effective in reducing localized flow disturbances around the piers and would probably prevent some debris from accumulating on these piers. The pier extensions did not significantly lower the water surface in the upstream channel or affect the flow distribution between the bypass culvert and the Guadalupe River. The effect of these pier extensions on scour depths near the piers is not known and the channel bed near the piers will have to be armored to prevent scour anyway, so the pier extensions would not be beneficial for this purpose. The pier extensions are not necessary on the highway piers, but pier extensions similar to those shown in Plate 24 aligned with the existing piers and constructed to the same width as the existing piers should be placed on the two existing piers at the Santa Clara St. Bridge and the San Fernando St. Bridge. These pier extensions will reduce debris accumulation and reduce the chances of flow problems caused by an excessive accumulation of debris. The left wall modification upstream from the Santa Clara St. Bridge should not be changed from the design shown in Plate 89 without further evaluation. Changes could possibly change the flow regime. Structural support modifications to the Santa Clara St. Bridge could be investigated as a method to increase the clearance under this bridge.

There is always a degree of uncertainty in a model study when the boundary roughness is generated with roughness elements and represents trees and natural vegetation. The additional experiments performed in a separate flume reduced the degree of uncertainty to a level considered acceptable by WES and SPK. However, if, during the construction of the project, additional features are added to

the channel which will increase the roughness, further effects should be evaluated. Trees planted in the channel or in the gabions on the side slopes of the channel could certainly impact the capacity of the channel and the bridges.

Multipurpose flood control channels are beneficial to the general public, but the primary function is to ensure that the design flow can be passed without excessive flooding. The Guadalupe River channel is a good example of a multi-purpose flood control channel with flood control, environmental, recreational, and aesthetic benefits. Providing these additional benefits resulted in many areas within the reach model studied having significant velocities and concentrated flows during the design discharge. These areas on the invert and the side slopes need adequate scour protection. Maintenance of the channel should be performed after flow events to remove excessive sediment deposits and repair minor scour damages.

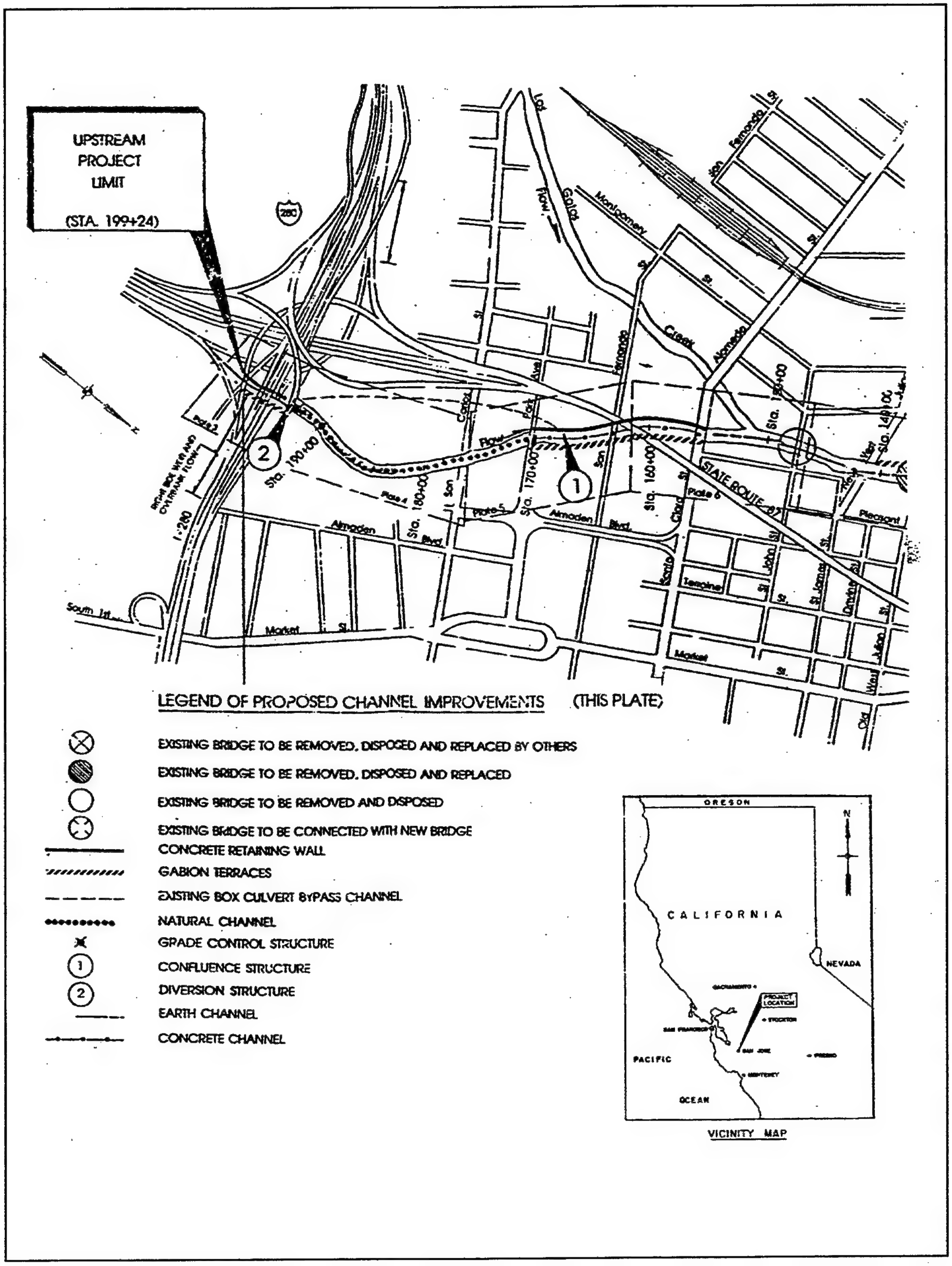


Figure 1. Location and vicinity map

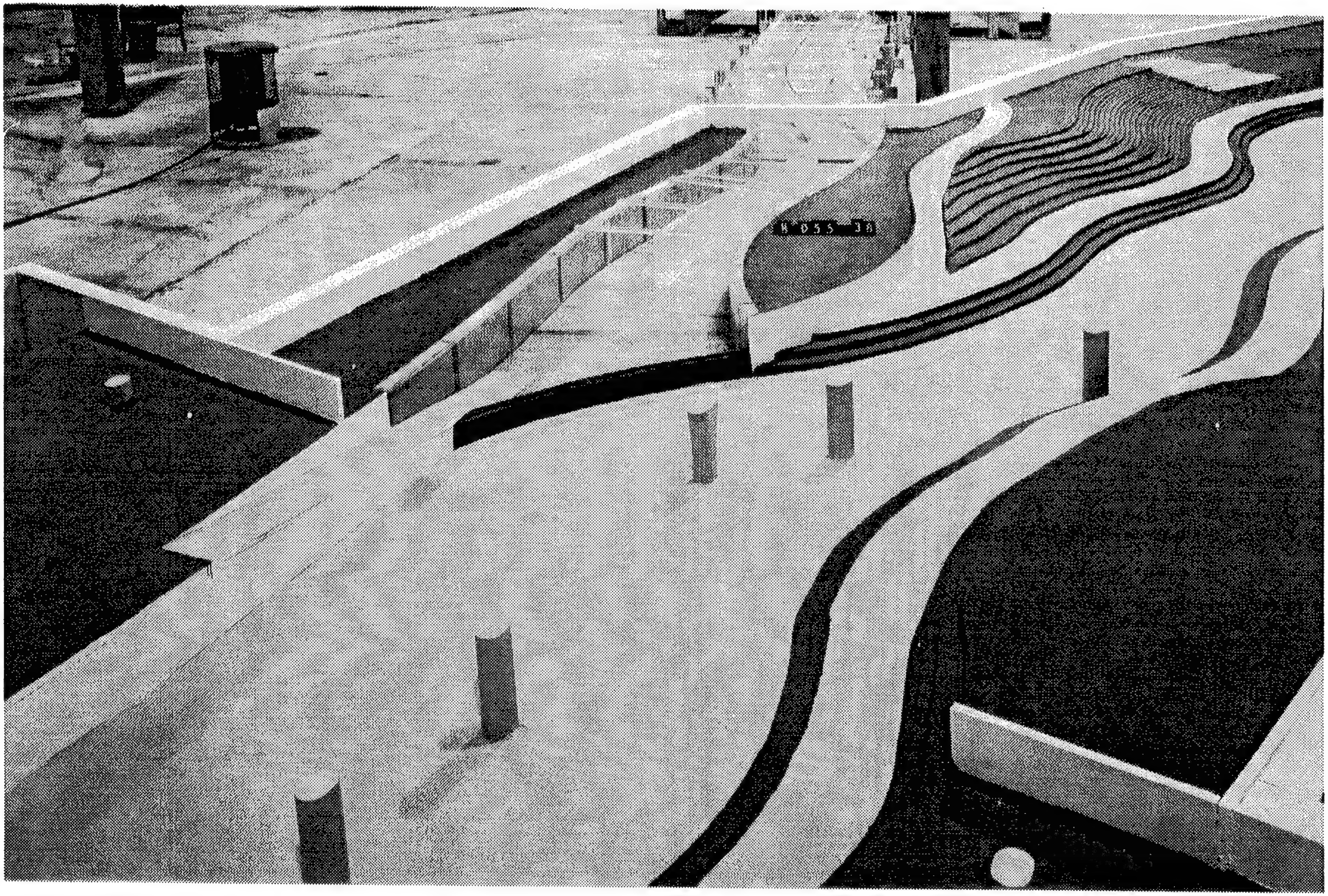

Figure 2. 1:25-scale model of the Guadalupe River bypass culvert

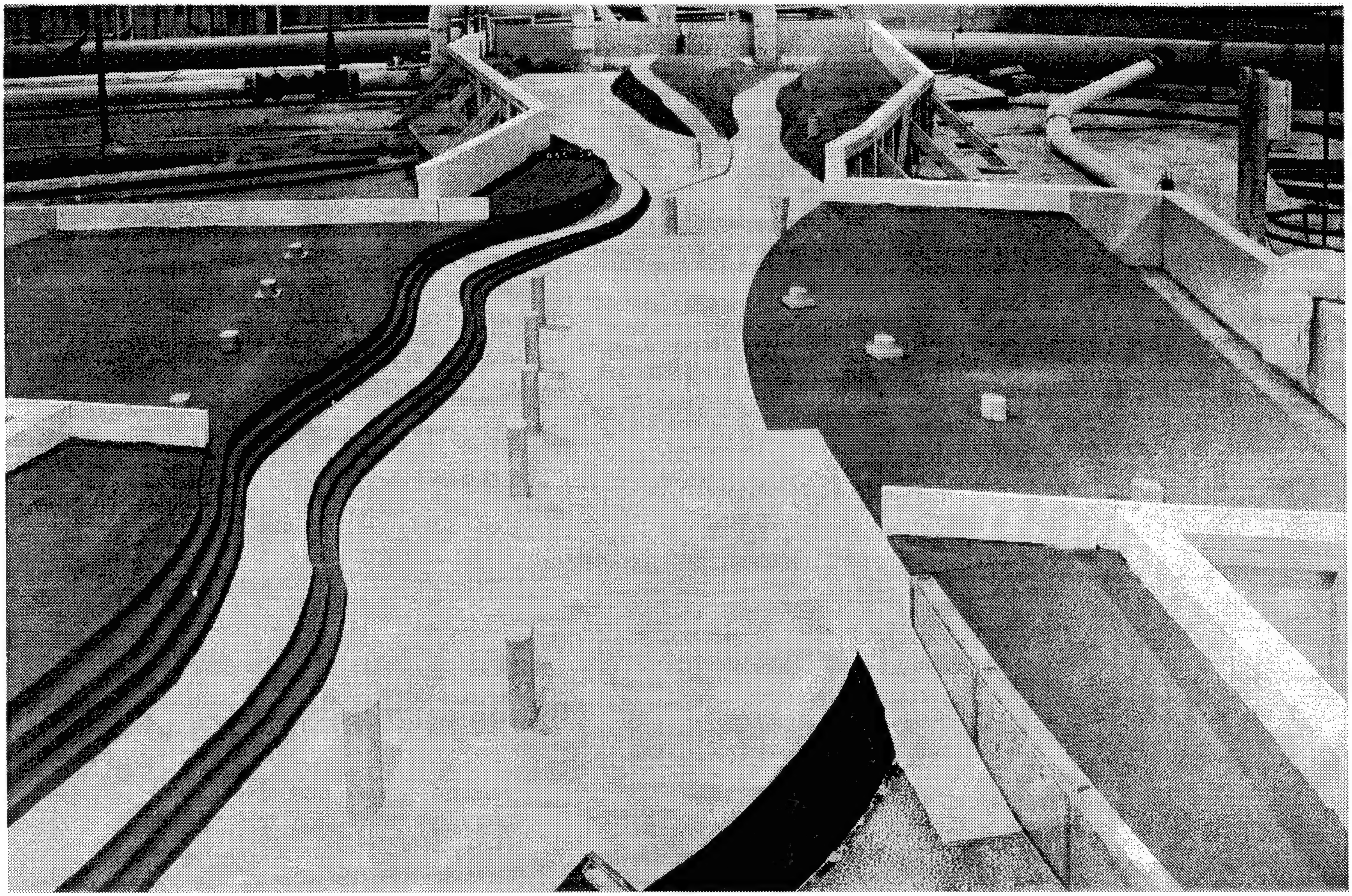

Figure 3. Looking upstream from the bypass entrance to the upstream model limit

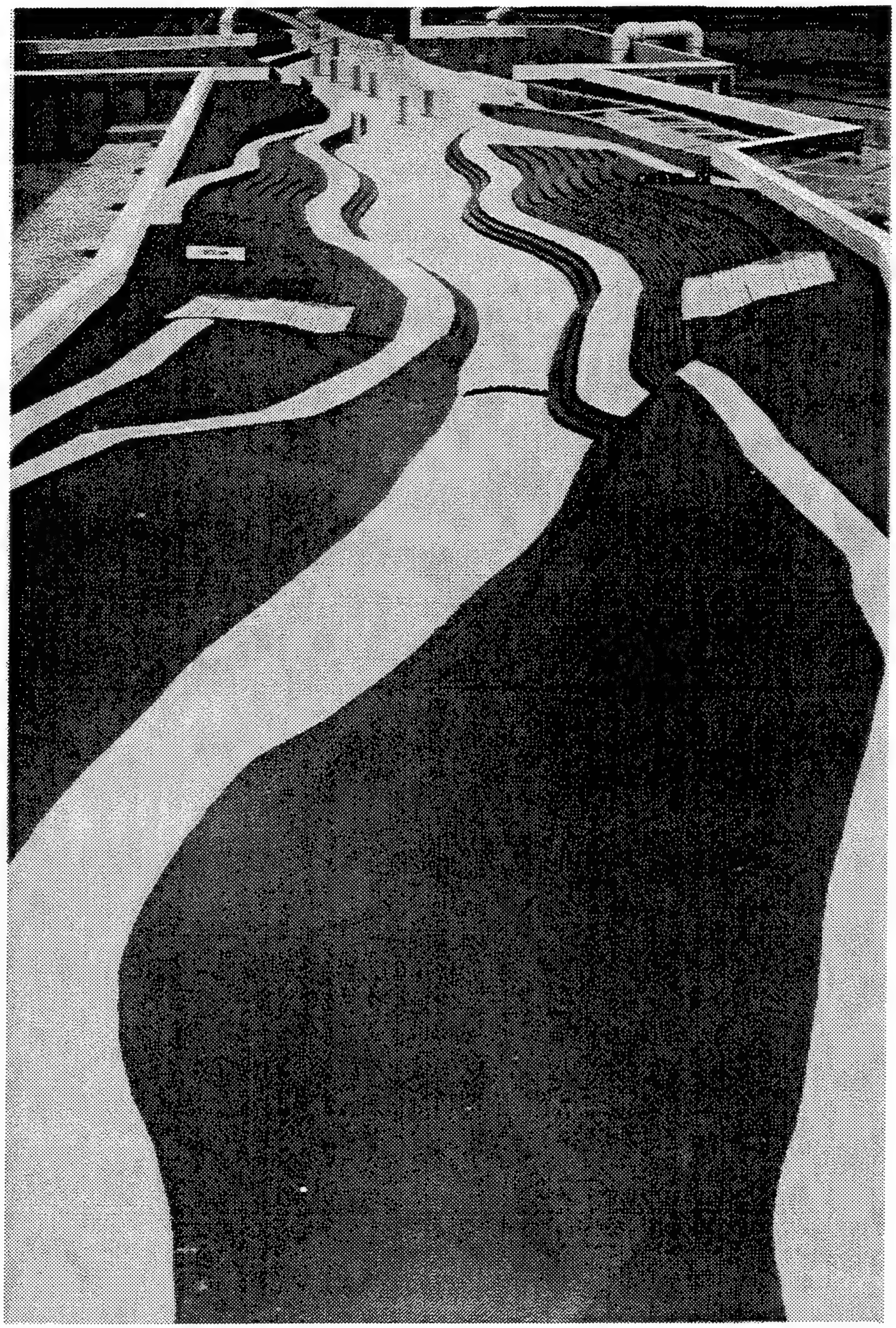

Figure 4. Looking upstream in the vicinity of Woz Way


Figure 5. Looking upstream in the vicinity of Auzerais Point

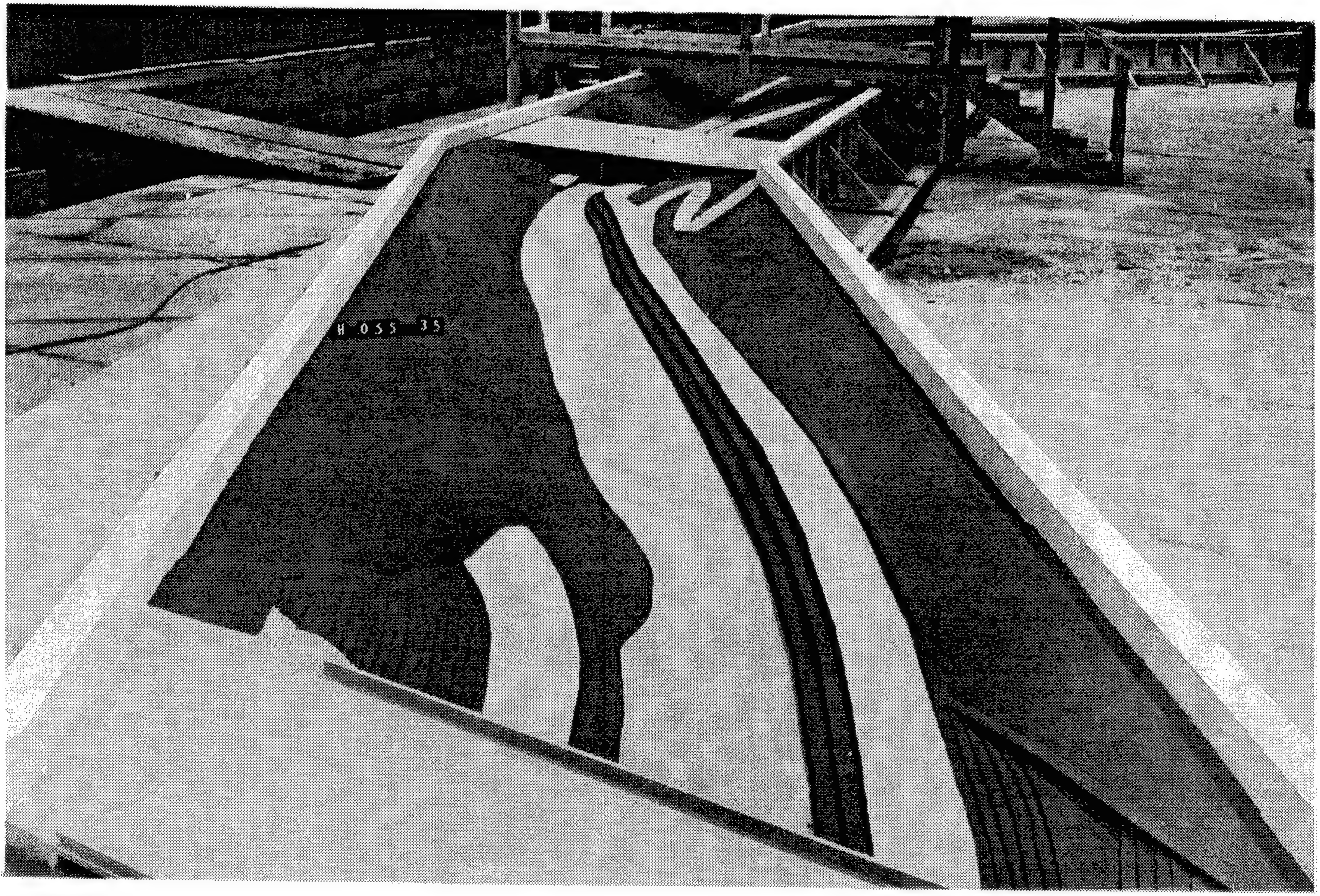


Figure 6. Looking upstream from Park Avenue to San Carlos Street

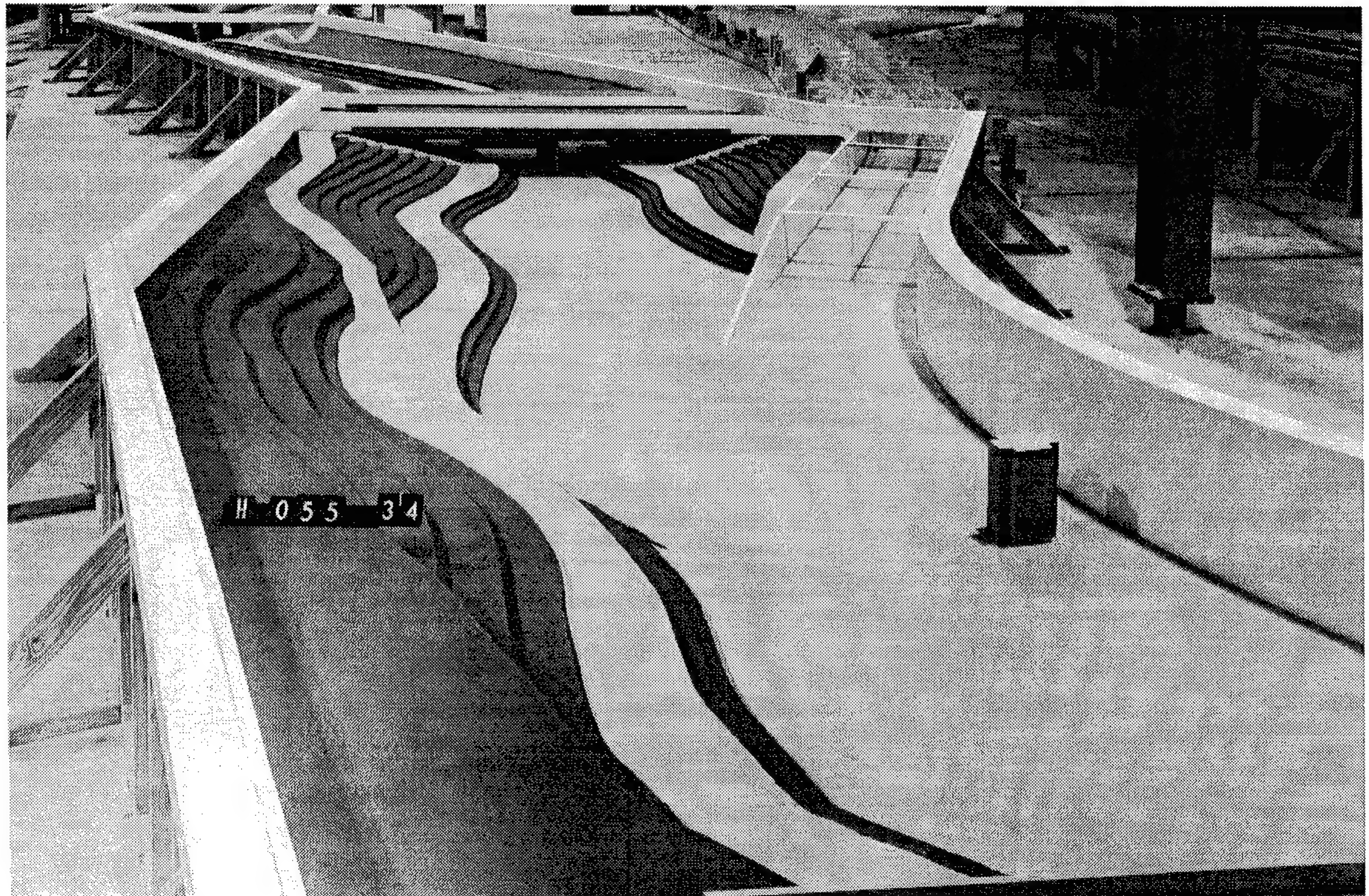


Figure 7. Looking upstream in the vicinity of the confluence

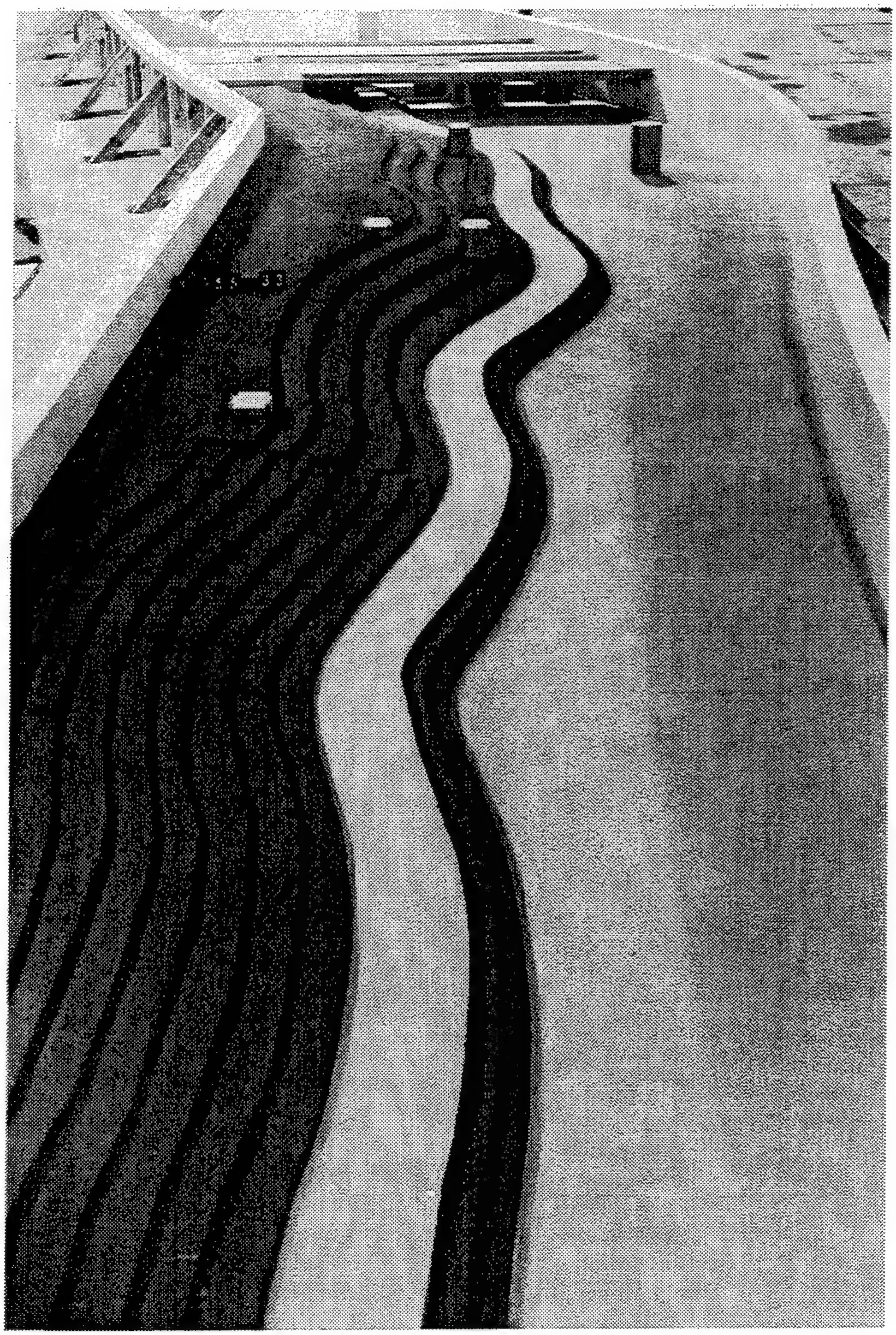

Figure 8. Looking upstream in the vicinity of San Fernando Street

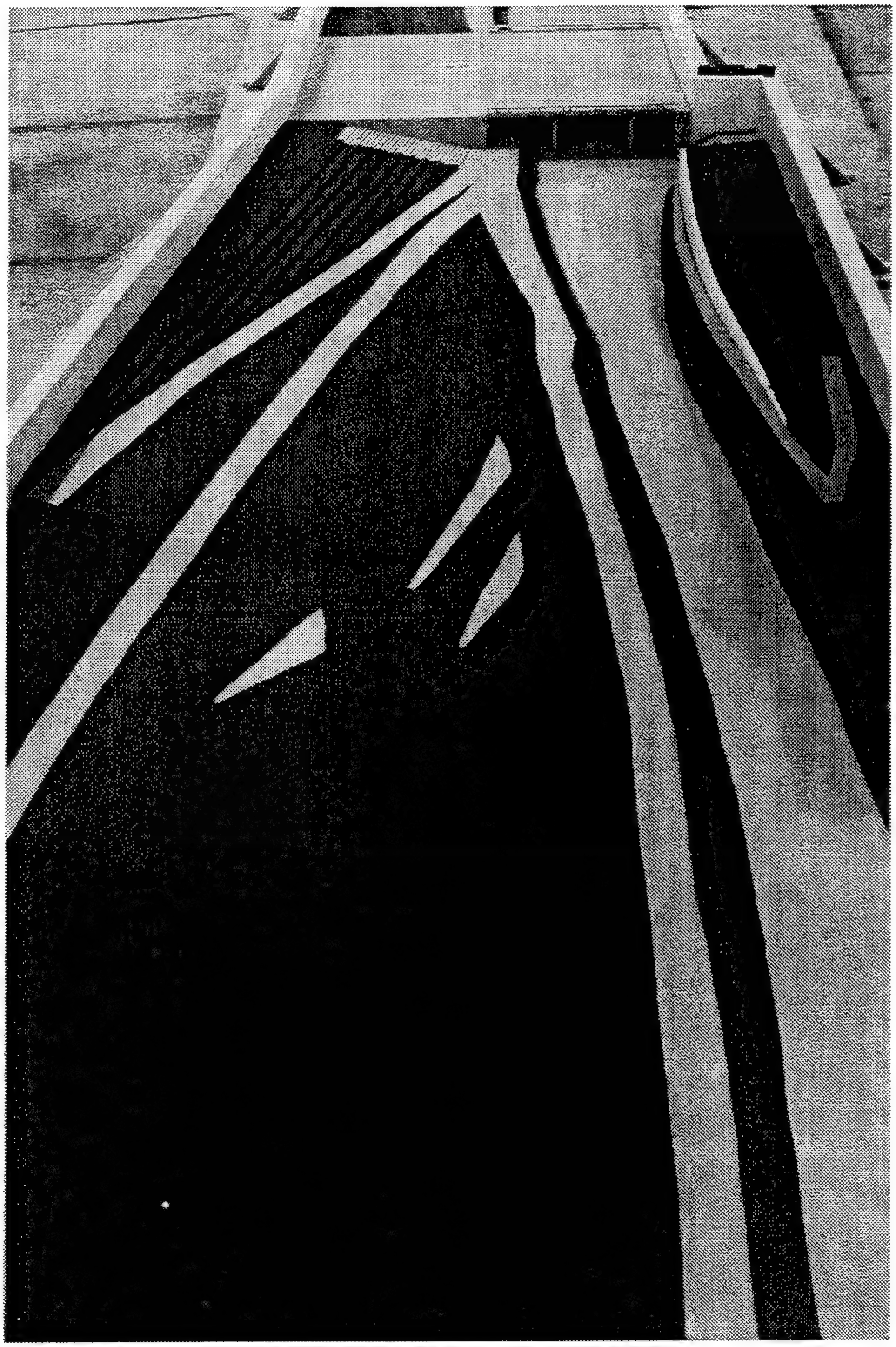

Figure 9. Looking upstream in the vicinity of Santa Clara Street

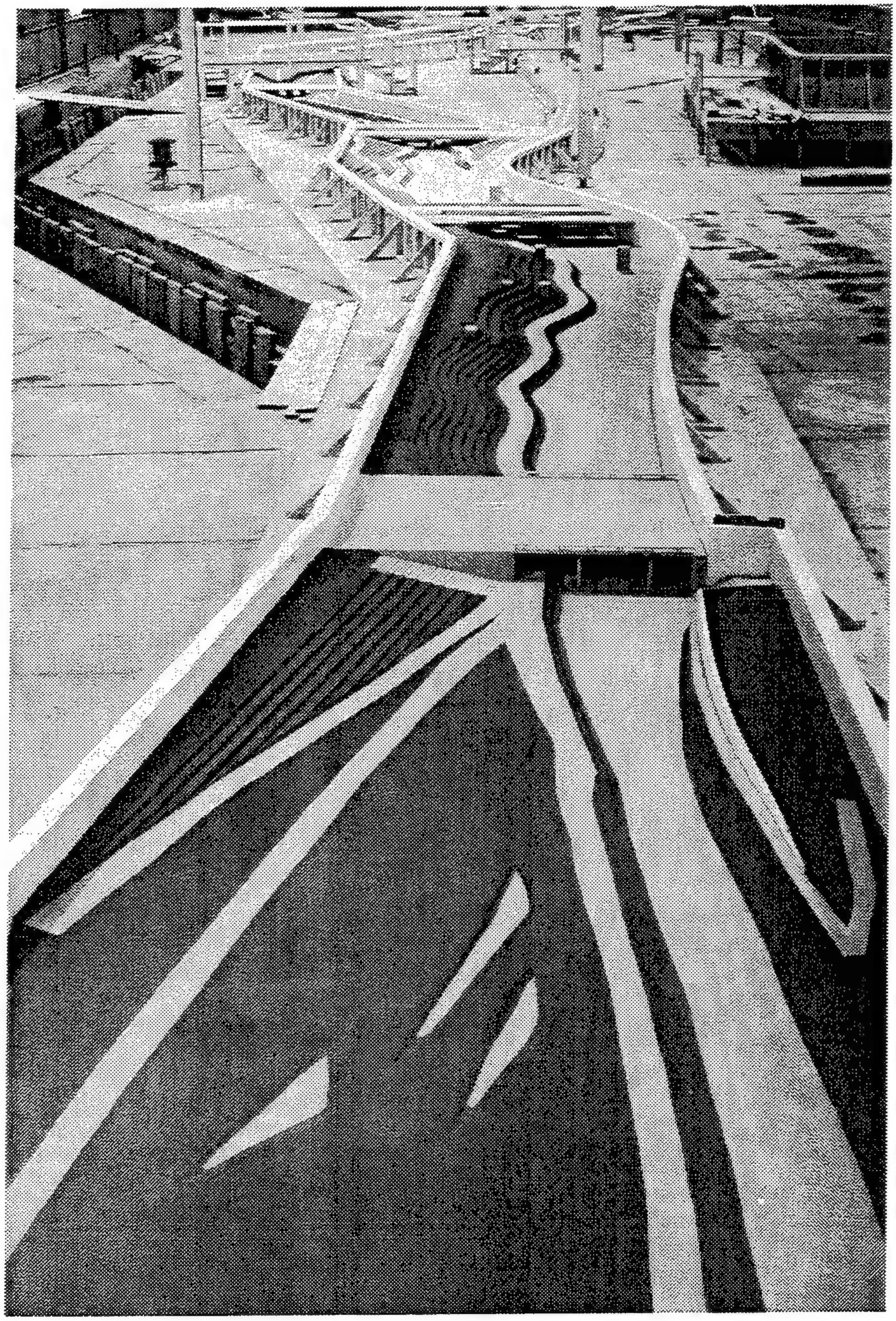

Figure 10. General view looking upstream from the downstream model limit

**Table 1**
**Water-Surface Elevations, Guadalupe River, Type 1 (Original) Design, Existing Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.6 at Sta 151+27**

| Station | Discharge, cfs | Water-Surface Elevation |
|---|---|---|
| 203+00 | 14,600 | 88.7 |
| 202+50 | | 88.9 |
| 202+00 | | 88.0 |
| 201+50 | | 87.6 |
| 201+00 | | 86.1 |
| 200+50 | | 86.0 |
| 200+00 | | 86.7 |
| 199+50 | | 86.1 |
| 199+00 | | 86.4 |
| 198+50 | | 86.8 |
| 198+00 | | 87.1 |
| 197+50 | | 87.0 |
| 197+00 | | 87.5 |
| 196+50 | | 86.5 |
| 196+00 | | 85.1 |
| 195+50 | | 85.0 |
| 195+00 | | 86.1 |
| 194+50 | 14,600 | 86.0 |
| 194+00 | 9,200 | 86.1 |
| 193+50 | | 86.0 |
| 193+00 | | 85.9 |
| 192+50 | | 85.9 |
| 192+00 | | 86.0 |
| 191+50 | | 85.7 |
| 191+00 | | 85.9 |
| 190+50 | | 85.8 |
| 190+00 | | 85.9 |
| 189+50 | 9,200 | 85.8 |
| 189+00 | 9,200 | 85.7 |
| 188+50 | | 85.8 |

(Sheet 1 of 4)

| Table 1 (Continued) | | |
|---|---|---|
| Station | Discharge, cfs | Water-Surface Elevation |
| 188+50 | | 85.6 |
| 187+50 | | 85.5 |
| 187+00 | | 85.1 |
| 186+50 | | 85.2 |
| 186+00 | | 85.2 |
| 185+50 | | 85.0 |
| 185+00 | | 84.8 |
| 184+50 | | 84.7 |
| 184+00 | | 84.6 |
| 183.50 | | 84.6 |
| 183+00 | | 83.9 |
| 182+50 | | 82.8 |
| 182+00 | | 83.9 |
| 181+50 | | 83.8 |
| 181+00 | | 82.9 |
| 180+50 | | 82.2 |
| 180+00 | | 83.3 |
| 179+50 | | 83.1 |
| 179+00 | | 83.7 |
| 178+50 | | 82.6 |
| 178+00 | | 83.8 |
| 177+50 | | 84.1 |
| 176+40 | | 82.5 |
| 176+00 | | 80.8 |
| 175+50 | | 79.1 |
| 175+00 | | 79.9 |
| 174+75 | | 81.1 |
| 174+50 | | 80.5 |
| 174+00 | | 79.3 |
| 173+50 | | 78.8 |
| 173.35 | | 80.0 |
| | | (Sheet 2 of 4) |

| Table 1 (Continued) | | |
|---|---|---|
| **Station** | **Discharge, cfs** | **Water-Surface Elevation** |
| 173+20 | | 78.9 |
| 173+00 | | 79.6 |
| 172+80 | | 80.5 |
| 172+50 | 9,200 | 79.6 |
| 172+00 | 9,200 | 80.1 |
| 171+50 | | 80.2 |
| 171+00 | | 80.1 |
| 170+80 | | 80.4 |
| 170+00 | | 80.3 |
| 169+40 | | 81.0 |
| 169+00 | | 80.9 |
| 168+50 | | 80.8 |
| 168+00 | | 80.7 |
| 167+50 | 9,200 | 80.9 |
| 167+00 | 14,600 | 80.8 |
| 166+50 | | 80.9 |
| 166+00 | | 80.8 |
| 165+50 | | 80.5 |
| 165+00 | | 80.4 |
| 164+50 | | 80.3 |
| 164+10 | | 79.9 |
| 163+50 | | 79.6 |
| 163+00 | | 79.1 |
| 162+50 | | 79.5 |
| 162+00 | | 79.0 |
| 161+50 | | 78.6 |
| 161+00 | | 78.8 |
| 160+50 | | 78.1 |
| 160+00 | | 77.7 |
| 159+50 | | 77.6 |
| 159+00 | | 77.7 |
| | | (Sheet 3 of 4) |

| Table 1 (Concluded) | | |
|---|---|---|
| Station | Discharge, cfs | Water-Surface Elevation |
| 158+50 | | 77.8 |
| 158+00 | | 77.7 |
| 157+50 | | 77.8 |
| 157+00 | | 77.6 |
| 156+50 | | 78.0 |
| 156+10 | | 77.8 |
| 155+00 | 14,600 | 77.6 |
| 154+50 | 14,600 | 77.5 |
| 154+00 | | 77.5 |
| 153+50 | | 77.3 |
| 153+00 | | 77.5 |
| 152+50 | | 77.6 |
| 152+00 | | 77.6 |
| 151+50 | | 77.7 |
| 151+00 | 14,600 | 77.7 |

**Table 2**
**Flow Depths in the Bypass Culvert Type 1 (Original) Design, Existing Conditions, Discharge at Sta 203+00 of Guadalupe River 14,600 cfs, Water-Surface Elevation of 76.0 at Sta 151+27 Guadalupe River**

| Sta | Center Line | Depth, ft[1] | | | |
|---|---|---|---|---|---|
| | | Left Box | | Right Box | |
| | | Left Wall | Right Wall | Left Wall | Right Wall |
| 36+00 | 11.5 | | | | |
| 35+00 | 12.0 | | | | |
| 35+00 | 12.7 | | | | |
| 34+90 | 12.3 | | | | |
| 34+85 | 4.3 | | | | |
| 34+80 | 9.0 | | | | |
| 34+50 | 10.6 | | | | |
| 34+00 | 11.8 | | | | |
| 33+95 | 12.6 | | | | |
| 33.90 | | — | 11.4 | 11.0 | — |
| 33+80 | | 10.0 | 7.4 | 8.9 | 10.0 |
| 33+50 | | 10.9 | 10.0 | 10.2 | 9.2 |
| 33+00 | | 9.0 | 10.5 | 8.7 | 9.7 |
| 31+97 | | 9.1 | 10.3 | 9.5 | 9.8 |
| 31+00 | | 9.8 | 9.6 | 10.2 | 9.2 |
| 30+00 | | 9.8 | 10.3 | 10.1 | 9.6 |
| 29+00 | | 10.1 | 10.7 | 10.7 | 10.1 |
| 28+00 | | 10.2 | 10.7 | 10.6 | 10.3 |
| 27+00 | | 10.5 | 11.2 | 11.0 | 10.6 |
| 26+00 | | 10.8 | 11.4 | 11.1 | 10.6 |
| 25+00 | | 10.7 | 11.1 | 11.6 | 10.9 |
| 24+00 | | 10.9 | 11.3 | 11.2 | 11.0 |
| 23+00 | | 11.1 | 11.5 | 11.5 | 11.2 |
| 22+00 | | 11.1 | 11.7 | 11.6 | 11.4 |

(Continued)

[1]Sides of channel are referenced to downstream direction.

| Table 2 (Concluded) | | | | | |
|---|---|---|---|---|---|
| Sta | Center Line | Depth, ft[1] | | | |
| | | Left Box | | Right Box | |
| | | Left Wall | Right Wall | Left Wall | Right Wall |
| 21+00 | | 11.4 | 11.9 | 11.7 | 11.6 |
| 20+00 | | 11.4 | 11.9 | 12.1 | 11.7 |
| 19+00 | | 11.6 | 11.7 | 12.1 | 11.3 |
| 18+00 | | 12.4 | 12.5 | 12.5 | 12.3 |
| 17+00 | | 12.6 | 12.7 | 12.6 | 12.4 |
| 16+00 | | 12.7 | 12.7 | 12.7 | 12.9 |
| 15+00 | | 13.0 | 13.1 | 13.1 | 13.1 |
| 14+00 | | 13.0 | 13.3 | 13.0 | 13.3 |
| 13+00 | | 13.1 | 13.3 | 13.5 | 13.4 |
| 12+00 | | 13.6 | 13.4 | 13.5 | 13.6 |
| 11+00 | | 14.0 | 14.0 | 14.0 | 13.9 |
| 10+00 | | 14.1 | — | — | 14.4 |

[1]Sides of channel are referenced to downstream direction.

**Table 3**
**Water-Surface Elevations, Guadalupe River, Type 1 (Original) Design, Existing Conditions, Discharge at Sta 203+00 9,100 cfs, Water-Surface Elevation of 73.9 at Sta 151+27**

| Station | Discharge, cfs | Water-Surface Elevation |
|---|---|---|
| 203+00 | 9,100 | 88.2 |
| 202+50 | | 88.2 |
| 202+00 | | 88.0 |
| 201+50 | | 87.7 |
| 201+00 | | 86.3 |
| 200+50 | | 84.0 |
| 200+00 | | 81.3 |
| 199+50 | | 79.5 |
| 199+20 | | 81.3 |
| 199+00 | | 81.5 |
| 198+75 | | 85.6 |
| 198+50 | | 80.4 |
| 198+25 | | 99.9 |
| 198+00 | | 98.9 |
| 197+50 | | 97.5 |
| 197+00 | | 97.4 |
| 196+50 | | 99.8 |
| 196+00 | | 99.7 |
| 195+50 | | 99.8 |
| 195+00 | | 82.7 |
| 194+50 | 9,100 | 82.6 |
| 194.00 | 5,200 | 82.5 |
| 193+50 | | 82.5 |
| 193+00 | | 82.4 |
| 192+50 | | 82.5 |
| 192+00 | | 82.8 |
| 191+50 | | 82.2 |
| 191+00 | | 82.3 |
| 190+50 | | 82.2 |
| 190+00 | | 82.3 |

(Sheet 1 of 4)

| Table 3 (Continued) | | |
|---|---|---|
| Station | Discharge, cfs | Water-Surface Elevation |
| 189+50 | | 82.4 |
| 189+00 | 5,200 | 82.3 |
| 188+50 | | 82.5 |
| 188+00 | | 82.6 |
| 187+50 | | 82.3 |
| 187+00 | | 82.0 |
| 186+50 | | 82.0 |
| 186+00 | | 82.0 |
| 185+50 | | 82.2 |
| 185+00 | | 81.9 |
| 184+50 | | 81.8 |
| 184+00 | | 81.7 |
| 183+50 | | 81.7 |
| 183+00 | | 81.3 |
| 182+50 | | 81.4 |
| 182+00 | | 77.8 |
| 181+50 | | 77.6 |
| 181+00 | | 77.3 |
| 180+50 | | 82.6 |
| 180+00 | | 80.4 |
| 179+50 | | 80.8 |
| 179+00 | | 80.6 |
| 178+50 | | 80.6 |
| 178+00 | | 81.0 |
| 177+50 | | 81.1 |
| 176+40 | | 80.0 |
| 176+00 | | 79.0 |
| 175+50 | | 76.3 |
| 175.25 | | 77.0 |
| 175.20 | | 78.0 |
| 175+00 | | 76.6 |

(Sheet 2 of 4)

**Table 3 (Continued)**

| Station | Discharge, cfs | Water-Surface Elevation |
|---|---|---|
| 174+75 | | 78.0 |
| 174+50 | | 77.5 |
| 174+00 | | 76.1 |
| 173+50 | | 74.8 |
| 173+00 | | 73.6 |
| 172+60 | | 74.4 |
| 172+50 | 5,200 | 75.3 |
| 172+25 | 5,200 | 74.6 |
| 172+15 | | 76.2 |
| 172+00 | | 74.6 |
| 171+90 | | 74.5 |
| 171+70 | | 76.4 |
| 171+60 | | 75.1 |
| 171+35 | | 76.6 |
| 171+20 | | 74.9 |
| 170+95 | | 76.0 |
| 170+80 | | 75.9 |
| 170+00 | | 75.7 |
| 169+40 | | 76.3 |
| 169+00 | | 76.2 |
| 168+50 | | 76.9 |
| 168+00 | | 76.4 |
| 167+50 | 5,200 | 76.3 |
| 167+00 | 9,100 | 76.1 |
| 166+50 | | 76.2 |
| 166+00 | | 76.4 |
| 165+50 | | 76.4 |
| 165+00 | | 76.1 |
| 164+50 | | 76.0 |
| 164+10 | | 75.7 |
| 163+50 | | 75.2 |

(Sheet 3 of 4)

| Table 3 (Concluded) | | |
|---|---|---|
| Station | Discharge, cfs | Water-Surface Elevaton |
| 163+00 | | 75.1 |
| 162+50 | | 75.4 |
| 162+00 | | 74.8 |
| 161+50 | | 74.6 |
| 161+00 | | 74.7 |
| 160+50 | | 74.0 |
| 160+00 | | 74.3 |
| 159+50 | | 73.8 |
| 159+00 | | 73.7 |
| 158+50 | | 73.8 |
| 158+00 | | 73.8 |
| 157+50 | | 73.8 |
| 157+00 | | 73.7 |
| 156+50 | | 74.0 |
| 156+10 | | 74.0 |
| 155+00 | 9,100 | 73.8 |
| 154+50 | 9,100 | 74.0 |
| 154+00 | | 73.8 |
| 153+50 | | 74.0 |
| 153+00 | | 73.9 |
| 152+50 | | 73.8 |
| 152+00 | | 74.1 |
| 151+50 | | 74.1 |
| 151+00 | 9,100 | 74.1 |

**Table 4**
**Flow Depths in the Bypass Culvert, Type 1 (Original) Design, Existing Conditions, Discharge at Sta 203+00 of Guadalupe River 9,100 cfs, Discharge in the Bypass Culvert 3,900 cfs, Water-Surface Elevation of 73.0 at Sta 151+27 Guadalupe River**

| Sta | Center Line | Depth, ft[1] | | | |
|---|---|---|---|---|---|
| | | Left Box | | Right Box | |
| | | Left Wall | Right Wall | Left Wall | Right Wall |
| 36+00 | 8.4 | | | | |
| 35+50 | 9.4 | | | | |
| 35+00 | 10.5 | | | | |
| 34+85 | 10.7 | | | | |
| 34+80 | 3.7 | | | | |
| 34+75 | 2.6 | | | | |
| 34+50 | 1.6 | | | | |
| 34+40 | 2.1 | | | | |
| 34.30 | 3.5 | | | | |
| 34+15 | 7.1 | | | | |
| 34+00 | 7.0 | | | | |
| 33+97 | 8.8 | | | | |
| 33+80 | | 7.2 | 4.7 | 3.2 | 3.4 |
| 33+50 | | 5.6 | 6.2 | 4.0 | 4.4 |
| 33+00 | | 6.9 | 6.7 | 3.3 | 5.6 |
| 32+00 | | 6.9 | 7.8 | 4.6 | 5.0 |
| 31+00 | | 6.4 | 6.3 | 4.4 | 3.5 |
| 30+00 | | 5.4 | 6.2 | 5.3 | 4.3 |
| 29+00 | | 7.0 | 7.6 | 6.3 | 5.9 |
| 28+00 | | 5.8 | 6.4 | 5.5 | 5.1 |
| 27+00 | | 7.3 | 7.5 | 6.6 | 6.6 |
| 26+00 | | 7.4 | 7.8 | 5.2 | 6.6 |
| 25+00 | | 7.0 | 7.7 | 7.0 | 6.7 |
| 24+00 | | 6.8 | 7.3 | 6.8 | 6.6 |

(Continued)

[1] Sides of channel are referenced to downstream direction.

| Table 4 (Concluded) | | | | | |
|---|---|---|---|---|---|
| | | Depths, ft[1] | | | |
| | | Left Box | | Right Box | |
| Sta | Center Line | Left Wall | Right Wall | Left Wall | Right Wall |
| 23+00 | | 7.3 | 7.8 | 7.2 | 6.5 |
| 22+00 | | 7.3 | 7.6 | 6.8 | 6.7 |
| 21+00 | | 7.1 | 7.7 | 7.0 | 8.4 |
| 20+00 | | 7.0 | 7.6 | 7.3 | 7.3 |
| 19+00 | | 6.5 | 6.3 | 7.6 | 7.0 |
| 18+00 | | 8.6 | 7.8 | 8.0 | 7.8 |
| 17+00 | | 8.3 | 8.4 | 8.0 | 7.8 |
| 16+00 | | 8.7 | 8.4 | 8.4 | 8.3 |
| 15+00 | | 8.4 | 8.6 | 8.3 | 8.5 |
| 14+00 | | 8.8 | 8.6 | 8.7 | 8.5 |
| 13+00 | | 8,8 | 9.0 | 8.8 | 9.0 |
| 12+00 | | 9.0 | 9.0 | 9.2 | 9.0 |
| 11+00 | | 9.4 | 9.6 | 9.4 | 9.6 |
| 10+00 | | 9.9 | — | — | 9.8 |

**Table 5**
**Comparison of Water-Surface Elevations, Discharge at Sta 203+00 of Guadalupe River 1,500 cfs, Water-Surface Elevation of 79.25 at Sta 190+00 Guadalupe River**

| WES Sta | Water-Surface Elevation | HRS Sta | Water-Surface Elevation |
|---|---|---|---|
| 202+70 | 81.9 | 719+00 | 82.87 |
| 200+62 | 80.1 | 716+92 | 79.81 |
| 198+18 | 79.68 | 714+48 | 79.58 |
| 196+50 | 79.93 | | |
| 195+00 | 79.63 | | |
| 192+70 | 79.48 | 709+00 | 79.77 |
| 190+40 | 79.25 | 705+00 | 79.26 |

Note: Weir crest elevation = 79.77

**Table 6**
**Guadalupe River and Bypass Culvert Flow Distribution, Type 2 Design, Weir el = 79.77**

| Discharge Source and Amount in cfs | | | | Total Discharge cfs | Guadalupe River Discharge | Bypass Culvert Discharge | Qbc/Qt |
|---|---|---|---|---|---|---|---|
| Natural Channel | Bypass Channel | Right OB | Left OB | | | | |
| 9,100 | | 2,000 | 3,500 | 14,600 | 7,100 | 7,500 | 0.51 |
| 9,100 | | | | 9,100 | 4,700 | 4,400 | 0.48 |
| 6,500 | | | | 6,500 | 4,100 | 2,400 | 0.37 |
| 4,800 | 9,800 | | | 14,600 | 7,400 | 7,200 | 0.49 |
| 2,600 | 6,500 | | | 9,100 | 4,600 | 4,500 | 0.49 |
| 1,600 | 4,900 | | | 6,500 | 3,800 | 2,700 | 0.42 |

Note: Manning's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel
Qbc = Discharge in the bypass culvert
Qt = Total Discharge

**Table 7**
**Guadalupe River Water-Surface Elevations, Type 2 Design, Existing Conditions, Discharge at Sta 203+00 14,600 cfs, Water-Surface Elevation of 77.6 at Sta 151+27**

| Station | Discharge cfs | Water-Surface Elevation |
|---|---|---|
| 203+00 | 14,600 | 90.3 |
| 202+50 | | 89.4 |
| 202+00 | | 89.5 |
| 201+50 | | 88.5 |
| 201+00 | | 88.0 |
| 200+50 | | 87.9 |
| 200+00 | | 88.2 |
| 199+50 | | 87.9 |
| 199+00 | | 88.2 |
| 198+50 | | 88.5 |
| 198+00 | | 88.7 |
| 197+50 | | 88.3 |
| 197+00 | | 88.1 |
| 196+50 | | 87.2 |
| 196+00 | | 87.0 |
| 195+50 | | 87.2 |
| 195+00 | | 87.2 |
| 194+50 | 14,600 | 87.3 |
| 194+00 | 7,100 | 87.3 |
| 193+50 | | 87.1 |
| 193+00 | | 87.0 |
| 192+50 | | 87.1 |
| 192+00 | | 87.0 |
| 191+50 | | 87.0 |
| 191+00 | | 87.2 |
| 190+50 | | 87.0 |
| 190+00 | | 87.3 |
| 189+50 | 7,100 | 87.1 |

(Sheet 1 of 4)

| Table 7 (Continued) | | |
|---|---|---|
| Station | Discharge cfs | Water-Surface Elevation |
| 189+00 | 7,100 | 87.1 |
| 188+50 | | 87.1 |
| 188+00 | | 86.8 |
| 187+50 | | 86.5 |
| 187+00 | | 86.3 |
| 186+50 | | 86.2 |
| 186+00 | | 86.1 |
| 185+50 | | 85.8 |
| 185+00 | | 85.5 |
| 184+50 | | 85.2 |
| 184+00 | | 85.1 |
| 183+50 | | 85.0 |
| 183+00 | | 84.5 |
| 182+50 | | 84.4 |
| 182+00 | | 84.4 |
| 181+50 | | 84.2 |
| 181+00 | | 84.0 |
| 180+50 | | 83.8 |
| 180+00 | | 83.6 |
| 179+50 | | 83.3 |
| 179+00 | | 83.2 |
| 178+50 | | 83.0 |
| 178+00 | | 83.1 |
| 177+50 | | 83.3 |
| 176.40 | | 82.6 |
| 176+00 | | 81.8 |
| 175+50 | | 81.7 |
| 175+00 | | 81.6 |
| 174+75 | | 81.4 |
| 174+50 | | 81.2 |
| 174+00 | | 80.8 |
| | | (Sheet 2 of 4) |

| Table 7 (Continued) | | |
|---|---|---|
| Station | Discharge cfs | Water-Surface Elevation |
| 173+00 | | 80.8 |
| 173+00 | | 80.8 |
| 172+50 | | 80.8 |
| 172+00 | 7,100 | 80.8 |
| 171+50 | | 80.7 |
| 171+00 | | 80.8 |
| 170+80 | | 80.7 |
| 170+20 | | 80.4 |
| 169+40 | | 80.7 |
| 169+00 | | 80.8 |
| 168+50 | | 80.8 |
| 168+00 | | 80.8 |
| 167+50 | 7,100 | 80.8 |
| 167+00 | 14,600 | 80.8 |
| 166+50 | | 80.8 |
| 166+00 | | 80.7 |
| 165+50 | | 80.5 |
| 165+00 | | 80.3 |
| 164+50 | | 80.3 |
| 164+10 | | 79.9 |
| 163+50 | | 79.5 |
| 163+00 | | 79.2 |
| 162+50 | | 79.7 |
| 162+00 | | 79.1 |
| 161+50 | | 78.9 |
| 161+00 | | 78.9 |
| 160+50 | | 78.3 |
| 160+00 | | 77.9 |
| 159+50 | | 77.9 |
| 159+00 | | 77.8 |
| 158+50 | | 77.9 |
| | | (Sheet 3 of 4) |

| Table 7 (Concluded) | | |
|---|---|---|
| Station | Discharge cfs | Water-Surface Elevation |
| 158+00 | | 77.9 |
| 157+50 | | 78.0 |
| 157+00 | | 77.9 |
| 156+50 | | 78.1 |
| 156+10 | | 78.2 |
| 155+00 | 14,600 | 77.8 |
| 154+50 | 14,600 | 77.9 |
| 154+00 | | 77.7 |
| 153+50 | | 77.5 |
| 153+00 | | 77.7 |
| 152+50 | | 77.8 |
| 152+00 | | 77.6 |
| 151+50 | | 77.7 |
| 151+00 | 14,600 | 77.6 |

**Table 8**
**Flow Depths in the Bypass Culvert, Type 2 Design, Existing Conditions, Discharge at Sta 203+00 of Guadalupe River 14,600 cfs, Discharge in Box Culvert 7,500 cfs, Water-Surface Elevation of 77.6 at Sta 151+27 Guadalupe River**

| Sta | Depth, ft[1] | | | | |
|---|---|---|---|---|---|
| | Centerline | Left Box | | Right Box | |
| | | Left Wall | Right Wall | Left Wall | Right Wall |
| 36+00 | 13.2 | | | | |
| 35+50 | 13.1 | | | | |
| 35+00 | 13.4 | | | | |
| 34+90 | 12.7 | | | | |
| 34+80 | 5.7 | | | | |
| 34+70 | 9.5 | | | | |
| 34+50 | 12.5 | | | | |
| 34+00 | 12.6 | | | | |
| 33.75 | | 10.0 | 8.2 | 10.7 | 10.6 |
| 33+50 | | 9.8 | 9.1 | 11.9 | 12.0 |
| 33+00 | | 9.2 | 9.7 | 9.9 | 11.0 |
| 32+00 | | 9.2 | 11.3 | 10.0 | 9.9 |
| 31+50 | | 10.4 | 9.1 | 8.9 | 9.1 |
| 31+25 | | 8.2 | 7.9 | 8.4 | 6.9 |
| 31+00 | | 9.0 | 8.3 | 10.6 | 10.9 |
| 30+50 | | 10.3 | 9.9 | 10.8 | 9.2 |
| 30+00 | | 9.2 | 8.9 | 10.3 | 10.3 |
| 29+00 | | 10.0 | 9.9 | 10.8 | 9.8 |
| 28+00 | | 10.3 | 10.6 | 10.5 | 9.9 |
| 27+00 | | 10.5 | 11.3 | 11.1 | 10.8 |
| 26+00 | | 11.2 | 11.6 | 11.7 | 11.3 |
| 25+00 | | 10.9 | 11.1 | 11.5 | 10.8 |
| 24+00 | | 10.7 | 11.4 | 11.3 | 11.0 |
| 23+00 | | 11.3 | 11.5 | 11.5 | 10.9 |
| 22+00 | | 11.3 | 11.7 | 11.6 | 11.3 |

(Continued)

[1]Sides of channel are referenced to downstream direction

| Table 8 (Concluded) | | | | | |
|---|---|---|---|---|---|
| | | Depth, ft[1] | | | |
| | | Left Box | | Right Box | |
| Sta | Center Line | Left Wall | Right Wall | Left Wall | Right Wall |
| 21+00 | | 11.3 | 11.7 | 11.7 | 11.3 |
| 20+00 | | 11.3 | 12.0 | 11.9 | 11.7 |
| 19+00 | | 11.6 | 11.3 | 12.1 | 11.4 |
| 18+00 | | 12.5 | 12.5 | 12.5 | 12.4 |
| 17+00 | | 12.6 | 12.6 | 12.5 | 12.6 |
| 16+10 | | 12.9 | 12.7 | 12.9 | 12.8 |
| 15+00 | | 13.1 | 13.0 | 13.0 | 13.0 |
| 14+00 | | 12.8 | 13.1 | 13.2 | 13.2 |
| 13+00 | | 13.1 | 13.2 | 13.6 | 13.3 |
| 12+00 | | 13.4 | 13.4 | 13.3 | 13.4 |
| 11+00 | | 13.8 | 13.7 | 13.7 | 13.7 |
| 10+00 | | 13.9 | | | 14.2 |

[1]Sides of channel are referenced to downstream direction

**Table 9**
**Guadalupe River Water-Surface Elevations, Type 2 Design, Future Conditions, Discharge at Sta 203+00 14,600 cfs, Water-Surface Elevation of 77.6 at Sta 151+27**

| Station | Discharge, cfs | Water-Surface Elevation |
|---|---|---|
| 203+00 | 14,600 | 89.2 |
| 202+50 | | 89.2 |
| 202+00 | | 89.1 |
| 201+50 | | 89.1 |
| 201+00 | | 89.2 |
| 200+50 | | 89.0 |
| 200+00 | | 88.8 |
| 199+50 | | 88.7 |
| 199+00 | | 88.3 |
| 198+50 | | 87.3 |
| 198+00 | | 86.9 |
| 197+50 | | 87.1 |
| 197+00 | | 86.9 |
| 196+50 | | 85.5 |
| 196+00 | | 85.7 |
| 195+50 | | 86.8 |
| 195+00 | | 86.8 |
| 194+50 | 14,600 | 87.1 |
| 194+00 | 7,400 | 86.8 |
| 193+50 | | 86.9 |
| 193+00 | | 87.0 |
| 192+50 | | 86.9 |
| 192+00 | | 87.0 |
| 191+50 | | 86.8 |
| 191+00 | | 87.0 |
| 190+50 | | 86.9 |
| 190+00 | | 86.9 |
| 189+50 | | 86.8 |
| 189+00 | 7,400 | 86.9 |
| 188+50 | | 86.8 |

(Sheet 1 of 4)

| Table 9 (Continued) | | |
|---|---|---|
| Station | Discharge, cfs | Water-Surface Elevation |
| 188+00 | | 86.5 |
| 187+50 | | 86.3 |
| 187+00 | | 86.1 |
| 186+50 | | 86.0 |
| 186+00 | | 85.8 |
| 185+50 | | 85.6 |
| 185+00 | | 85.2 |
| 184+50 | | 85.0 |
| 184+00 | | 84.8 |
| 183+50 | | 84.8 |
| 183+00 | | 84.4 |
| 182+50 | | 84.2 |
| 182+00 | | 84.2 |
| 181+50 | | 84.1 |
| 181+00 | | 83.8 |
| 180+50 | | 83.4 |
| 180+00 | | 83.3 |
| 179+50 | | 83.1 |
| 179+00 | | 83.0 |
| 178+50 | | 82.8 |
| 178+00 | | 82.8 |
| 177+50 | | 82.9 |
| 176+40 | | 82.4 |
| 176+00 | | 81.7 |
| 175+50 | | 81.3 |
| 175+00 | | 81.2 |
| 174+75 | | 81.0 |
| 174+50 | | 80.7 |
| 174+00 | | 80.8 |
| 173+50 | | 80.8 |
| 173+00 | | 80.7 |

(Sheet 2 of 4)

| Table 9 (Continued) | | |
|---|---|---|
| Station | Discharge, cfs | Water-Surface Elevation |
| 172+50 | 7,4000 | 80.7 |
| 172+00 | 7,400 | 80.6 |
| 171+50 | | 80.6 |
| 171+00 | | 80.7 |
| 170+80 | | 80.7 |
| 170+00 | | 80.6 |
| 169+40 | | 80.8 |
| 169+00 | | 81.0 |
| 168+50 | | 80.9 |
| 168+00 | | 84.5 |
| 167+50 | 7,400 | 80.8 |
| 167+00 | 14,600 | 80.7 |
| 166+50 | | 80.7 |
| 166+00 | | 80.6 |
| 165+50 | | 80.5 |
| 165+00 | | 80.0 |
| 164+50 | | 80.2 |
| 164+10 | | 79.9 |
| 163+50 | | 79.3 |
| 163+00 | | 79.3 |
| 162+50 | | 79.7 |
| 162+00 | | 79.1 |
| 161+50 | | 78.7 |
| 161+00 | | 78.7 |
| 160+50 | | 78.1 |
| 160+00 | | 77.7 |
| 159+50 | | 77.5 |
| 159+00 | | 77.6 |
| 158+50 | | 77.7 |
| 158+00 | | 77.9 |
| 157+50 | | 77.8 |
| | | (Sheet 3 of 4) |

| Table 9 (Concluded) | | |
|---|---|---|
| Station | Discharge, cfs | Water-Surface Elevation |
| 157+00 | | 77.7 |
| 156+50 | | 78.0 |
| 156+10 | | 78.0 |
| 155+00 | 14,600 | 77.7 |
| 154+50 | 14,600 | 77.6 |
| 154+00 | | 77.5 |
| 153+50 | | 77.3 |
| 153+00 | | 77.5 |
| 152+50 | | 77.4 |
| 152+00 | | 77.9 |
| 151+50 | | 77.7 |
| 151+00 | 14,600 | 77.6 |

**Table 10**
**Flow Depths in the Bypass Culvert, Type 2 Design, Future Conditions, Discharge at Sta 203+00+00 of Guadalupe River 14,600 cfs, Discharge in Box Culvert 7,200 cfs, Water-Surface Elevation of 77.6 at Sta 151+27 Guadalupe River**

| Sta | Center Line | Depth, ft[1] | | | |
|---|---|---|---|---|---|
| | | Left Box | | Right Box | |
| | | Left Wall | Right Wall | Left Wall | Right Wall |
| 36+00 | 12.4 | | | | |
| 35+50 | 12.3 | | | | |
| 35+00 | 13.7 | | | | |
| 34+90 | 13.3 | | | | |
| 34+80 | 5.6 | | | | |
| 34+70 | 10.9 | | | | |
| 34+50 | 12.5 | | | | |
| 34+00 | 12.9 | | | | |
| 33+75 | | 11.2 | 8.9 | 10.7 | 11.4 |
| 33+50 | | 9.6 | 10.3 | 12.2 | 13.0 |
| 33+25 | | 11.1 | 12.2 | 11.3 | 11.2 |
| 33+00 | | 10.1 | 10.3 | 10.6 | 11.5 |
| 32+50 | | 9.7 | 11.7 | 10.7 | 11.1 |
| 32+00 | | 9.6 | 11.2 | 10.1 | 10.4 |
| 31+50 | | 9.0 | 9.6 | 9.2 | 10.2 |
| 31+25 | | 9.3 | 8.1 | 10.5 | 9.2 |
| 31+00 | | 9.2 | 9.7 | 11.0 | 11.3 |
| 30+50 | | 10.6 | 10.8 | 11.3 | 10.6 |
| 30+00 | | 9.7 | 9.4 | 10.6 | 10.2 |
| 29+00 | | 10.4 | 11.3 | 11.1 | 10.8 |
| 28+00 | | 11.0 | 11.6 | 11.0 | 10.5 |
| 27+00 | | 10.8 | 11.4 | 11.2 | 10.9 |
| 26+00 | | 11.3 | 11.8 | 11.7 | 11.5 |
| 25+00 | | 11.4 | 12.0 | 11.9 | 11.7 |

(Continued)

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| Table 10 (Concluded) | | | | | |
|---|---|---|---|---|---|
| | | Depth, ft[1] | | | |
| | | Left Box | | Right Box | |
| Sta | Center Line | Left Wall | Right Wall | Left Wall | Right Wall |
| 24+00 | | 11.4 | 12.0 | 11.5 | 11.1 |
| 23+00 | | 11.5 | 11.7 | 11.1 | 10.8 |
| 22+00 | | 11.5 | 12.1 | 11.6 | 11.6 |
| 21+00 | | 11.4 | 11.8 | 12.1 | 11.8 |
| 20+00 | | 11.5 | 11.6 | 11.9 | 11.7 |
| 19+00 | | 11.7 | 11.6 | 12.2 | 11.4 |
| 18+00 | | 13.0 | 12.8 | 12.8 | 12.3 |
| 17+00 | | 12.9 | 12.7 | 12.7 | 12.5 |
| 16+00 | | 12.8 | 12.8 | 12.6 | 12.8 |
| 15+00 | | 13.1 | 13.1 | 12.8 | 12.9 |
| 14+00 | | 12.8 | 12.9 | 13.3 | 13.0 |
| 13+00 | | 13.2 | 13.3 | 13.5 | 13.3 |
| 12+00 | | 13.2 | 13.3 | 13.4 | 13.3 |
| 11+00 | | 13.6 | 13.6 | 13.7 | 13.7 |
| 10+00 | | 13.8 | | | 14.2 |

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**Table 11**
**Guadalupe River and Bypass Culvert Flow Distribution**
**Type 2 Design**
**Weir El = 79.02**

| Discharge Source and Amount in cfs | | | | Total Discharge cfs | Guadalupe River Discharge | Bypass Culvert Discharge | Qbc/Qt |
|---|---|---|---|---|---|---|---|
| Natural Channel | Bypass Channel | Right OB | Left OB | | | | |
| 9,100 | | 2,000 | 3,500 | 14,600 | 7,400 | 7,200 | 0.49 |
| 9,100 | | | | 9,100 | 4,600 | 4,500 | 0.49 |
| 6,500 | | | | 6,500 | 3,800 | 2,700 | 0.42 |
| 4,800 | 9,800 | | | 14,600 | 7,000 | 7,600 | 0.52 |
| 2,600 | 6,500 | | | 9,100 | 4,600 | 4,500 | 0.49 |
| 1,600 | 4,900 | | | 6,500 | 3,700 | 2,800 | 0.43 |

Note: Manning's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel
Obc = Discharge in the bypass culvert
Qt = Total discharge

**Table 12**
**Guadalupe River Water-Surface Elevations, Type 2 Design, Future Conditions, Ogee Weir El 79.02, Discharge at Sta 203+00 14,600 cfs**

| Sta | Discharge cfs | Elevation |
|---|---|---|
| 197+00 | 14,600 | 86.8 |
| 195+00 | | 86.8 |
| 193+00 | 7,000 | 86.8 |
| 190+00 | | 86.8 |
| 187+00 | | 86.0 |
| 184+00 | | 84.9 |
| 181+00 | | 83.8 |
| 178+50 | | 82.6 |
| 176+00 | | 81.5 |
| 173+50 | | 80.5 |
| 172+00 | | 80.4 |
| 168+00 | 7,000 | 80.6 |
| 166+00 | 14,600 | 80.5 |
| 164+50 | | 80.0 |
| 161+50 | | 78.8 |
| 157+00 | | 77.5 |
| 153+00 | | 77.7 |
| 151+00 | | 77.7 |

Table 13
Flow Depths in the Bypass Culvert, Type 2 Design, Future Conditions, Ogee Weir El. 79.02, Discharge at Sta 203+00 of Guadalupe River 14,600 cfs, Discharge in Bypass Culvert 7,600 cfs, Water-Surface Elevation at Sta 151+27 Guadalupe River 77.6

| Sta | Center Line | Depth, ft[1] | | | |
|---|---|---|---|---|---|
| | | Left Box | | Right Box | |
| | | Left Wall | Right Wall | Left Wall | Right Wall |
| 36+00 | 12.4 | | | | |
| 35+50 | 13.1 | | | | |
| 35+00 | 13.4 | | | | |
| 34+90 | 12.8 | | | | |
| 34+80 | 6.4 | | | | |
| 34+70 | 9.9 | | | | |
| 34+50 | 12.6 | | | | |
| 34+00 | 13.5 | | | | |
| 33+50 | | 8.8 | 9.0 | 12.0 | 12.2 |
| 33+00 | | 10.0 | 9.8 | 10.1 | 10.4 |
| 32+50 | | 9.9 | 11.0 | 10.3 | 10.4 |
| 26+00 | | 11.0 | 11.3 | 11.4 | 10.8 |
| 14+50 | | 13.0 | 13.0 | 13.1 | 12.9 |
| 14+00 | | 12.9 | 13.0 | 13.2 | 13.4 |
| 12+50 | | 10.2 | 12.9 | 13.4 | 13.3 |
| 12+00 | | 13.1 | 13.2 | 13.1 | 13.1 |
| 11+50 | | 13.3 | 13.2 | 13.1 | 13.3 |
| 11+00 | | 13.7 | 13.6 | 13.4 | 13.5 |
| 10+50 | | 13.6 | 13.7 | 13.4 | 13.8 |
| 10+00 | | 13.6 | | | 14.1 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

[1]Sides of channel are referenced to downstream direction

**Table 14**
**Santa Clara Bridge Water-Surface Elevations, Discharge 14,600 cfs, Future Conditions**

| Station | Water-Surface Elevation | | | | | |
|---|---|---|---|---|---|---|
| | Left Wall | Left Side Pier A | Rt. Side Pier A | Left Side Pier B | Rt. Side Pier B | Right Wall |
| 156+10 | 77.7 | 78.0 | 78.0 | 77.9 | 78.0 | 77.4 |
| 156+00 | 77.6 | 75.9 | 76.4 | 76.2 | 76.7 | 76.9 |
| 155+96 | 77.6 | 75.8 | 76.5 | 75.0 | 76.2 | 77.0 |
| 155+90 | 77.3 | 78.1 | 77.7 | 77.9 | 77.9 | 77.4 |
| 155+50 | 77.5 | 77.4 | 77.5 | 77.5 | 77.3 | 77.5 |
| 155+10 | 77.5 | 77.0 | 77.0 | 76.9 | 77.2 | 77.5 |

Note: Pier A is pier on left side of channel looking downstram.
Water-surface elevation at Sta 151+27, Guadalupe River, 77.6

**Table 15**
**Santa Clara Bridge Water-Surface Elevations, Pier Extensions on Piers A and B, Discharge 14,600 cfs, Future Conditions**

| Station | Water-Surface Elevation | | | | | |
|---|---|---|---|---|---|---|
| | Left Wall | Left Side Pier A | Rt. Side Pier A | Left Side Pier B | Rt. Side Pier B | Right Wall |
| 156+15 | 77.7 | 77.7 | 77.9 | 77.7 | 78.0 | 77.5 |
| 156+13 | 77.6 | 76.7 | 77.3 | 76.0 | 79.1 | 77.5 |
| 156+10 | 77.5 | 76.4 | 76.6 | 75.4 | 77.3 | 77.6 |
| 156.07 | 77.4 | 76.8 | 76.8 | 76.4 | 77.1 | 77.0 |
| 156+00 | 77.1 | 77.1 | 76.9 | 77.2 | 76.8 | 76.8 |
| 155+50 | 77.3 | 77.1 | 77.5 | 77.6 | 77.5 | 77.3 |
| 155+10 | 77.3 | 76.8 | 76.8 | 76.8 | 77.1 | 77.5 |

Note: Pier A is pier on left side of channel looking downstream.
Water-surface elevation at Sta 151+27, Guadalupe River, 77.6.

**Table 16**
**Santa Clara Bridge Water-Surface Elevations, Channel Narrowed Downstream, Discharge 14,600 cfs, Future Conditions**

| Station | Water-Surface Elevation | | | | | |
|---|---|---|---|---|---|---|
| | Left Wall | Left Side Pier A | Rt. Side Pier A | Left Side Pier B | Rt. Side Pier B | Right Wall |
| 156+10 | 77.9 | 77.9 | 77.9 | 78.0 | 78.0 | 77.2 |
| 155+95 | 77.5 | 76.6 | 76.4 | 75.0 | 75.3 | 77.1 |
| 155+90 | 77.3 | 78.0 | 77.6 | 77.6 | 77.7 | 77.0 |
| 155+50 | 77.4 | 77.5 | 77.5 | 77.4 | 77.5 | 77.3 |
| 155+10 | 77.5 | 77.5 | 77.0 | 76.9 | 76.9 | 77.2 |

Note: Pier A is pier on left side of channel looking downstream.
Water-surface elevation at Sta 151+27, Guadalupe River, 776.

**Table 17**
**Santa Clara Bridge Water-Surface Elevations,**
**Discharge 14,600 cfs, Future Conditions, Without Service Road,**
**With Debris on Piers**

| Station | Water-Surface Elevation | | | | | |
|---|---|---|---|---|---|---|
| | Left Wall | Left Side Pier A | Rt. Side Pier A | Left Side Pier B | Rt. Side Pier B | Right Wall |
| 156+10 | 77.7 | 78.0 | 77.9 | 77.9 | 78.0 | 77.6 |
| 156+00 | 77.7 | 79.0 | 79.2 | 78.0 | 79.3 | 77.7 |
| 155+95 | 77.8 | 77.2 | 77.4 | 75.9 | 75.8 | 77.5 |
| 155+90 | 77.6 | 78.1 | 78.0 | 77.9 | 77.9 | 77.8 |
| 155+50 | 77.7 | 77.7 | 77.8 | 77.7 | 77.7 | 77.7 |
| 155+10 | 77.6 | 77.5 | 77.5 | 77.4 | 77.3 | 77.7 |

Note: Pier A is pier on left side of channel looking downstream.
Water-surface elevation at Sta 151+27, Guadalupe River, 776.

Table 18
Guadalupe River and Bypass Culvert Flow Distribution, for Various Modifications, Total Inflow = 14,600 cfs

| Discharge Conditions | Type Modification | Weir Elevation | Guadalupe River Discharge cfs | Bypass Culvert Discharge cfs | Obc/QT |
|---|---|---|---|---|---|
| Existing | Sediment Buildup In Front of Weir | 79.02 | 7,250 | 7,350 | 0.50 |
| Existing | Type 2 Bypass Entrance | 79.02 | 7,100 | 7,500 | 0.51 |
| Future | Type 2 Bypass Entrance | 79.02 | 7,050 | 7,550 | 0.52 |
| Future | Type 2 Bypass Entrance<br>Type 3 Weir | 79.02 | 7,600 | 7,000 | 0.48 |
| Future | Type 3 Bypass Entrance<br>Type 3 Weir | 79.02 | 7,250 | 7,350 | 0.50 |
| Future | Type 3 Bypass Entrance<br>Type 3 Weir<br>Type 3 U/S Channel | 79.02 | 7,100 | 7,500 | 0.51 |
| Future | Type 2 Bypass Entrance<br>Type 4 Weir | 79.02 | 7,400 | 7,200 | 0.49 |
| Future | Type 4 Weir | 79.02 | 7,150 | 7,450 | 0.51 |
| Future | Type 5 Weir | 79.02 | 7,550 | 7,550 | 0.48 |
| Future | Bypass Weir Removed | NO WEIR | 6,850 | 7,750 | 0.53 |
| Future | Bypass Weir Removed<br>4.5 ft High Weir in River | NO WEIR | 6,700 | 7,900 | 0.54 |
| Future | Bypass Weir Removed<br>8.3 ft High Weir in River | NO WEIR | 6,500 | 8,100 | 0.55 |
| Future | TW EL 87.5, Sta 190+00<br>(HRS Conditions) | 79.77 | 6,950 | 7,650 | 0.52 |

(Continued)

Note: Manning's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel
Obc = Discharge in the bypass culvert
Qt = Total discharge

**Table 18 (Concluded)**

| Discharge Conditions | Type Modification | Weir Elevation | Guadalupe River Discharge cfs | Bypass Culvert Discharge cfs | Qbc/Qt |
|---|---|---|---|---|---|
| Future | Entrance Pier Removed | 79.77 | 7,000 | 7,600 | 0.52 |
| Future | TW EL 87.5, Sta 190+00 (HRS Conditions) Entrance Pier Removed | 79.77 | 6,700 | 7,900 | 0.54 |
| Future | Type 4 U/S Channel | 79.77 | 7,000 | 7,600 | 0.52 |
| Future | Type 5 U/S Channel | 79.77 | 6,500 | 8,100 | 0.55 |
| Existing | Type 5 U/S Channel | 79.77 | 7,300 | 7,300 | 0.50 |
| Future | Type 6 U/S Channel | 79.77 | 6,500 | 8,100 | 0.55 |
| Existing | Type 6 U/S Channel | 79.77 | 7,100 | 7,500 | 0.51 |

Note: Manning's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel.
Qbc = Discharge in the bypass culvert.
Qt = Total discharge.

**Table 19**
**Guadalupe River Water-Surface Elevations, Type 4 Bypass Entrance, Type 10 Upstream Channel, Future Conditions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.6 at Sta 151+27**

| Sta | Discharge cfs | Elevation |
|---|---|---|
| 200+00 | 14,600 | 89.3 |
| 199+50 | | 89.0 |
| 199+00 | | 88.5 |
| 198+50 | | 89.3 |
| 198+00 | | 87.1 |
| 197+50 | | 87.1 |
| 197+00 | | 87.7 |
| 196+50 | | 86.3 |
| 196+00 | | 88.6 |
| 195+50 | | 88.2 |
| 195+00 | | 88.3 |
| 194+50 | | 88.7 |
| 194+00 | | 88.9 |
| 193+50 | 6,850 | 88.7 |
| 193+00 | | 88.5 |
| 192+50 | | 88.5 |
| 192+00 | | 88.5 |

**Table 20**
**Guadalupe River Water-Surface Elevations, Type 4 Bypass Entrance, Type 11 Upstream Channel, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.6 at Sta 151+27**

| Sta | Discharge cfs | Existing Conditions WS Elev. | Future Conditions WS Elev. |
|---|---|---|---|
| 200+00 | 14,600 | 92.8 | 92.2 |
| 199+50 | | 92.1 | 92.1 |
| 199+00 | | 92.6 | 91.4 |
| 198+50 | | 92.6 | 90.0 |
| 198+00 | | 92.2 | 88.7 |
| 197+50 | | 91.4 | 88.8 |
| 197+00 | | 91.2 | 89.4 |
| 196+50 | | 90.1 | 89.2 |
| 196+00 | | 90.6 | 89.0 |
| 195+50 | | 89.3 | 88.8 |
| 195+00 | | 88.1 | 87.9 |
| 194+50 | | 88.5 | 88.0 |
| 194+00 | | 88.4 | 88.1 |
| 193+50 | 6,650 Exist. and 6,900 Future | 88.3 | 87.9 |
| 193+00 | | 88.3 | 87.9 |
| 192+50 | | 88.2 | 88.0 |
| 192+00 | | 88.2 | 87.9 |
| 191+50 | | | 87.8 |

Table 21
Guadalupe River Water-Surface Elevations, Type 5 Bypass Entrance, Type 11 Upstream Channel,
Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27

| Stations | Water-Surface Elevations | | | | | | |
|---|---|---|---|---|---|---|---|
| | W/O Pier Extensions | | Type 1 Pier Extensions | | Future Conditions | | |
| | Existing Condition | Future Conditions | Existing Condition | Future Conditions | Type 2 Pier Extensions | Type 3 Pier Extensions | Type 4 Pier Extensions |
| 200+00 | 91.8 | 92.0 | 91.0 | 91.9 | 91.9 | 92.0 | 91.6 |
| 199+50 | 92.8 | 92.0 | 91.9 | 92.1 | 92.2 | 92.1 | 91.5 |
| 199+00 | 91.4 | 91.4 | 91.9 | 91.6 | 91.3 | 91.5 | 91.0 |
| 198+50 | 91.7 | 90.0 | 91.6 | 88.4 | 88.3 | 88.8 | 87.9 |
| 198+00 | 91.6 | 88.0 | 91.7 | 87.9 | 87.8 | 88.1 | 87.5 |
| 197+50 | 91.1 | 87.8 | 91.0 | 87.9 | 87.9 | 87.9 | 87.5 |
| 197+00 | 90.7 | 87.9 | 90.8 | 88.2 | 88.6 | 88.0 | 87.5 |
| 196+50 | 89.9 | 88.2 | 90.6 | 87.9 | 88.6 | 88.8 | 87.1 |
| 196+00 | 89.7 | 88.4 | 89.8 | 88.6 | 88.6 | 88.4 | 87.5 |
| 195+50 | 88.0 | 88.1 | 88.6 | 88.2 | 88.2 | 87.7 | 88.0 |
| 195+00 | 86.0 | 86.3 | 85.7 | 86.5 | 86.5 | 86.6 | 85.5 |
| 194+50 | 86.5 | 87.7 | 86.6 | 87.0 | 87.5 | 87.2 | 87.0 |
| 194+00 | 86.8 | 86.7 | 87.0 | 87.4 | 87.0 | 87.2 | 86.5 |
| 193+50 | 86.8 | 86.7 | 87.2 | 86.9 | 86.9 | 86.8 | 86.5 |
| 193+00 | 86.8 | 87.0 | 86.9 | 86.6 | 86.8 | 86.8 | 86.4 |
| 192+50 | 86.8 | 86.7 | 86.8 | 86.7 | 86.6 | 86.7 | 86.4 |
| 192+00 | 86.8 | 86.7 | 86.8 | 86.6 | 86.8 | 86.8 | 86.5 |

**Table 22**
**Guadalupe River Water-Surface Elevations, Type 5 Bypass Entrance, Type 12 Upstream Channel, Type 1 Pier Extensions, Future Conditions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Water-Surface Elevation |
|---|---|---|
| 200+00 | 14,600 | 91.4 |
| 199+50 | | 91.4 |
| 199+00 | | 90.9 |
| 198+50 | | 88.1 |
| 198+00 | | 87.7 |
| 197+50 | | 87.1 |
| 197+00 | | 87.2 |
| 196+50 | | 87.2 |
| 196+00 | | 87.5 |
| 195+50 | | 87.6 |
| 195+00 | | 87.2 |
| 194+50 | | 87.5 |
| 194+00 | | 87.6 |
| 193+50 | 6,900 | 87.1 |
| 193+00 | | 87.2 |
| 192+50 | | 87.2 |
| 192+00 | | 87.2 |

**Table 23**
**Guadalupe River Water-Surface Elevations, Type 5 Bypass Entrance, Type 13 Upstream Channel, Type 1 Pier Extensions, Existing Conditions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Elevation |
|---|---|---|
| 200+00 | 14,600 | 90.2 |
| 199+50 | | 91.3 |
| 199+00 | | 91.2 |
| 198+50 | | 91.4 |
| 198+00 | | 91.2 |
| 197+50 | | 90.3 |
| 197+00 | | 90.1 |
| 196+50 | | 89.7 |
| 196+00 | | 88.8 |
| 195+50 | | 87.2 |
| 195+00 | | 86.7 |
| 194+50 | | 87.8 |
| 194+00 | | 87.5 |
| 193+50 | 7,150 | 87.2 |
| 193+00 | | 87.3 |
| 192+50 | | 87.3 |
| 192+00 | | 87.2 |

**Table 24**
**Guadalupe River Water-Surface Elevations, Type 5 Bypass Entrance, Type 14 Upstream Channel, Type 5 Pier Extensions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Future Conditions Water-Surface Elevation | Existing Conditions Water-Surface Elevations |
|---|---|---|---|
| 200+50 | 14,600 | 91.4 | 90.5 |
| 200+00 | | 91.4 | 91.4 |
| 199+50 | | 91.4 | 91.3 |
| 199+00 | | 91.1 | 91.6 |
| 198+50 | | 90.3 | 91.4 |
| 198+00 | | 88.8 | 90.7 |
| 197+50 | | 88.0 | 90.2 |
| 197+00 | | 88.0 | 90.0 |
| 196+50 | | 88.4 | 89.2 |
| 196+00 | | 88.1 | 88.8 |
| 195+50 | | 87.3 | 87.5 |
| 195+00 | | 86.9 | 86.4 |
| 194+50 | | 87.3 | 87.2 |
| 194+00 | | 87.1 | 87.4 |
| 193+50 | 6750 Future and Existing Conditions | 87.0 | 87.1 |
| 193+00 | | 86.9 | 87.0 |
| 192+50 | | 86.8 | 87.1 |
| 192+00 | | 86.8 | 87.2 |

**Table 25**
**Guadalupe River Water-Surface Elevations, Type 5 Bypass Entrance, Type 15 Upstream Channel, Type 5 Pier Extensions, Future Conditions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevations of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Elevation |
|---|---|---|
| 200+50 | 14,600 | 91.2 |
| 200+00 | | 90.9 |
| 199+50 | | 90.9 |
| 199+00 | | 91.0 |
| 198+50 | | 90.3 |
| 198+00 | | 89.0 |
| 197+50 | | 88.8 |
| 197+00 | | 88.8 |
| 196+50 | | 88.9 |
| 196+00 | | 88.2 |
| 195+50 | | 87.5 |
| 195+00 | | 86.7 |
| 194+50 | | 87.2 |
| 194+00 | | 86.8 |
| 193+50 | 6,500 | 86.7 |
| 190+00 | | 86.9 |
| 192+50 | | 86.8 |
| 192+00 | | 86.7 |

**Table 26**
**Guadalupe River Water-Surface Elevations, Type 6 Bypass Entrance, Type 17 Upstream Channel, Type 5 Pier Extensions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Future Water-Surface Elevation | Existing Water-Surface Elevations |
|---|---|---|---|
| 200+50 | 14,600 | 91.2 | 90.6 |
| 200+00 | | 90.9 | 90.7 |
| 199+50 | | 90.9 | 90.8 |
| 199+00 | | 90.9 | 90.7 |
| 198+50 | | 90.4 | 91.1 |
| 198+00 | | 89.1 | 89.8 |
| 197+50 | | 89.1 | 90.1 |
| 197+00 | | 89.0 | 90.3 |
| 196+50 | | 88.6 | 89.6 |
| 196+00 | | 88.3 | 88.7 |
| 195+50 | | 87.4 | 87.3 |
| 195+00 | | 86.4 | 86.3 |
| 194+50 | | 87.2 | 87.4 |
| 194+00 | | 87.2 | 87.1 |
| 193+50 | 6,330 Future, 6,560 Existing Cond. | 86.8 | 86.9 |
| 193+00 | | 86.7 | 86.8 |
| 192+50 | | 86.3 | 86.3 |
| 192+00 | | 86.4 | 86.4 |

**Table 27**
**Guadalupe River Water-Surface Elevations, Type 7 Bypass Entrance, Type 18 Upstream Channel, Type 6 Pier Extensions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevations of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Future Water-Surface Elevation | Existing Water-Surface Elevations |
|---|---|---|---|
| 200+50 | 14,600 | 91.4 | 90.7 |
| 200+00 | | 91.1 | 91.2 |
| 199+50 | | 90.9 | 91.0 |
| 199+00 | | 90.6 | 91.1 |
| 198+50 | | 89.5 | 91.2 |
| 198+00 | | 88.6 | 90.1 |
| 197+50 | | 88.2 | 89.9 |
| 197+00 | | 87.9 | 89.7 |
| 196+50 | | 86.2 | 88.6 |
| 196+00 | | 86.7 | 87.8 |
| 195+50 | | 86.2 | 86.5 |
| 195+00 | | 85.9 | 85.5 |
| 194+50 | | 87.2 | 86.5 |
| 194+00 | | 86.8 | 86.7 |
| 193+50 | 6,500 Future and Existing Cond. | 86.6 | 86.6 |
| 193+00 | | 86.7 | 86.7 |
| 192+50 | | 86.7 | 86.8 |
| 192+00 | | 86.5 | 86.8 |

**Table 28**
**Guadalupe River Water-Surface Elevations, Type 18 Upstream Channel, Type 6 Pier Extensions, Future Conditions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevations of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Future Water-Surface Elevation | Existing Water-Surface Elevations |
|---|---|---|---|
| 200+50 | 14,600 | 91.7 | 91.5 |
| 200+00 | | 91.3 | 91.1 |
| 199+50 | | 91.3 | 91.1 |
| 199+00 | | 91.1 | 90.9 |
| 198+50 | | 89.8 | 89.5 |
| 198+00 | | 88.8 | 88.9 |
| 197+50 | | 88.9 | 88.5 |
| 197+00 | | 88.4 | 88.2 |
| 196+50 | | 86.8 | 86.4 |
| 196+00 | | 87.0 | 87.0 |
| 195+50 | | 87.0 | 86.3 |
| 195+00 | | 85.6 | 85.6 |
| 194+50 | | 86.9 | 86.8 |
| 194+00 | | 86.6 | 86.5 |
| 193+50 | 6,540 T 8 BE and 6,560 T 9 | 86.4 | 86.3 |
| 193+00 | | 86.7 | 86.7 |
| 192+50 | | 86.9 | 86.8 |
| 192+00 | | 86.8 | 86.8 |

Table 29
Guadalupe River Water-Surface Elevations, Type 18 Upstream Channel, Type 6 Pier Extensions, Type 8 Bypass Entrance, Future Conditions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27

| Dist. From U/S End, ft | | Water-Surface Elevation | |
|---|---|---|---|
| Left Side | Right Side | Left Side | Right Side |
| -13.50 | 0.00 | 86.8 | 86.9 |
| -6.75 | 15.00 | 85.8 | 83.4 |
| 0.00 | 28.75 | 88.9 | 84.4 |
| 12.00 | 52.50 | 91.9 | 85.4 |
| 44.50 | 82.50 | 86.6 | 85.7 |
| 77.25 | 112.50 | 88.3 | 84.6 |
| 82.50 | 138.75 | 85.4 | 84.1 |
| 95.00 | | 87.6 | |
| 112.50 | | 85.7 | |
| 125.50 | | 86.8 | |
| 138.75 | | 85.7 | |

**Table 30**
**Guadalupe River Water-Surface Elevations, Type 18 Upstream Channel, Type 6 Pier Extensions, Type 9 Bypass Entrance, Future Conditions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Dist. From U/S End, ft | | Water-Surface Elevation | |
|---|---|---|---|
| Left Side | Right Side | Left Side | Right Side |
| -13.50 | 0.00 | 86.7 | 86.3 |
| -6.75 | 17.00 | 85.9 | 85.1 |
| 0.00 | 28.75 | 86.3 | 86.2 |
| 17.00 | 52.50 | 89.6 | 86.8 |
| 44.50 | 82.50 | 86.0 | 86.3 |
| 77.25 | 112.50 | 87.4 | 84.9 |
| 82.50 | 138.75 | 84.8 | 84.7 |
| 95.00 | | 87.2 | |
| 112.50 | | 85.3 | |
| 125.50 | | 86.6 | |
| 138.50 | | 85.1 | |

**Table 31**
**Guadalupe River Water-Surface Elevations, Type 18 Upstream Channel, Type 6 Pier Extensions, Future Conditions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Type 7 BE Water-Surface Elevation | Type 10 BE Water-Surface Elevations |
|---|---|---|---|
| 200+50 | 14,600 | 91.4 | 91.5 |
| 200+00 | | 91.1 | 91.1 |
| 199+50 | | 90.9 | 90.9 |
| 199+00 | | 90.6 | 90.9 |
| 198+50 | | 89.5 | 89.5 |
| 198+00 | | 88.6 | 88.9 |
| 197+50 | | 88.2 | 88.7 |
| 197+00 | | 87.9 | 88.2 |
| 196+50 | | 86.2 | 86.6 |
| 196+00 | | 86.7 | 87.0 |
| 195+50 | | 86.2 | 86.3 |
| 195+00 | | 85.9 | 85.4 |
| 194+50 | | 87.2 | 86.8 |
| 194+00 | | 86.8 | 86.4 |
| 193+50 | 6,500 Type 7; 6,400 Type 10 | 86.6 | 86.5 |
| 193+00 | | 86.7 | 86.7 |
| 192+50 | | 86.7 | 86.8 |
| 192+00 | | 86.5 | 86.7 |

**Table 32**
**Guadalupe River Bypass Culvert Flow Distributions, Discharge at Sta 203+00, 14,600 cfs, Type 18 Upstream Channel, Type 6 Pier Extensions, Future Conditions, Ogee Weir El 79.77, Water-Surface Elevations of 77.0 at Sta 151+27**

| Bypass Entrance Design | Culvert Discharge cfs | Left Side Discharge cfs | Right Side Discharge cfs |
|---|---|---|---|
| Type 11 | 8140 | 3960 | 4180 |
| Type 12 | 7840 | 4030 | 3810 |
| Type 13 | 7980 | 4020 | 3960 |

**Table 33**
**Guadalupe River and Bypass Culvert Flow Distribution**
**Total Inflow = 14,600 cfs**

| Discharge Conditions | Type Modification | Guadalupe River Discharge cfs | Bypass Culvert Discharge cfs | Qbc/Qt | Water-Surface Elevation Sta 199+50 |
|---|---|---|---|---|---|
| Future | Type 4 Bypass Entrance<br>Type 9 Upstream Channel | 9,300 | 5,300 | 0.36 | |
| Future | Type 4 Bypass Entrance<br>Type 10 Upstream Channel | 7,750 | 6,850 | 0.47 | 89.0 |
| Future | Type 4 Bypass Entrance<br>Type 11 Upstream Channel | 7,700 | 6,900 | 0.47 | 92.1 |
| Existing | Type 4 Bypass Entrance<br>Type 11 Upstream Channel | 7,950 | 6,650 | 0.46 | |
| Future | Type 5 Bypass Entrance<br>Type 11 Upstream Channel | 6,550 | 8,050 | 0.55 | 92.0 |
| Existing | Type 5 Bypass Entrance<br>Type 11 Upstream Channel | 6,750 | 7,850 | 0.54 | 92.8 |
| Future | Type 5 Bypass Entrance<br>Type 11 Upstream Channel<br>Type 1 Pier Extensnions | 6,400 | 8,200 | 0.56 | 91.9 |
| Existing | Type 5 Bypass Entrance<br>Type 11 Upstream Channel<br>Type 1 Pier Extensions | 6,600 | 8,000 | 0.55 | 91.9 |
| Future | Type 5 Bypass Extrance<br>Type 11 Upstream Channel<br>Type 2 Pier Extensions | 6,500 | 8,050 | 0.55 | 92.2 |

(Sheet 1 of 4)

Note: Manning's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel.
Qbc = Discharge in the bypass culvert.
Qt = Total discharge.

## Table 33 (Continued)

| Discharge Conditions | Type Modification | Guadalupe River Discharge cfs | Bypass Culvert Discharge cfs | Qbc/Qt | Water-Surface Elevation Sta 199+50 |
|---|---|---|---|---|---|
| Future | Type 5 Bypass Entrance<br>Type 11 Upstream Channel<br>Type 3 Pier Extensions | 6,550 | 8,050 | 0.55 | 92.2 |
| Future | Type 5 Bypass Entrance<br>Type 11 Upstream Channel<br>Type 4 Pier Extensions | 6,550 | 8,050 | 0.55 | 91.5 |
| Future | Type 5 Bypass Entrance<br>Type 12 Upstream Channel<br>Type 1 Pier Extensions | 6,900 | 7,700 | 0.53 | 91.4 |
| Future | Type 5 Bypass Entrance<br>Type 13 Upstream Channel<br>Type 1 Pier Extensions | 6,750 | 7,850 | 0.54 | |
| Existing | Type 5 Bypass Entrance<br>Type 13 Upstream Channel<br>Type 1 Pier Extensions | 7,150 | 7,450 | 0.51 | 91.3 |
| Future | Type 5 Bypass Entrance<br>Type 14 Upstream Channel<br>Type 5 Pier Entensions | 6,750 | 7,850 | 0.54 | 91.4 |
| Existing | Type 5 Bypass Entrance<br>Type 14 Upstream Channel<br>Type 5 Pier Extensions | 6,750 | 7,850 | 0.54 | 91.3 |
| Future | Type 5 Bypass Entrance<br>Type 15 Upstream Channel<br>Type 5 Pier Extensions | 6,500 | 8,100 | 0.54 | 90.9 |

(Sheet 2 of 4)

Note: Mannings's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel
Qbc = Discharge in the bypass culvert
Qt = Total discharge

## Table 33 (Continued)

| Discharge Conditions | Type Modification | Guadalupe River Discharge cfs | Bypass Culvert Discharge cfs | Qbc/Qt | Water-Surface Elevation Sta 199+50 |
|---|---|---|---|---|---|
| Future | Type 6 Bypass Entrance<br>Type 17 Upstream Channel<br>Type 5 Pier Extensions | 6,330 | 8,270 | 0.57 | 91.3 |
| Existing | Type 6 Bypass Entrance<br>Type 17 Upstream Channel<br>Type 5 Pier Extensions | 6,560 | 8,040 | 0.55 | 90.8 |
| Future | Type 7 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,500 | 8,100 | 0.55 | 90.9 |
| Existing | Type 7 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,500 | 8,100 | 0.55 | 91.0 |
| Future | Type 8 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,530 | 8,070 | 0.55 | 91.3 |
| Future | Type 9 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,560 | 8,040 | 0.55 | 91.1 |
| Future | Type 10 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,600 | 8,000 | 0.55 | 90.9 |
| Future | Type 10 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,600 | 8,000 | 0.55 | 90.9 |

(Sheet 3 of 4)

Note: Mannings's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel
Qbc = Discharge in the bypass culvert
Qt = Total discharge

## Table 33 (Concluded)

| Discharge Conditions | Type Modification | Guadalupe River Discharge cfs | Bypass Culvert Discharge cfs | Qbc/Qt | Water-Surface Elevation Sta 199+50 |
|---|---|---|---|---|---|
| Future | Type 11 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,460 | 8,140 | 0.56 | |
| Future | Type 12 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,760 | 7,840 | 0.54 | |
| Future | Type 13 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,620 | 7,980 | 0.55 | |

(Sheet 4 of 4)

Note: Manning's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel
Qbc = Discharge in the bypass culvert
Qt = Total discharge

**Table 34**
**Guadalupe River Water-Surface Elevations, Type 18 Design Upstream Channel, Type 9 Design Bypass Entrance, Type 6 Design Pier Extensions, Type 2 Design Left Bank Near Santa Clara Bridge, Fountain at Confluence, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevationof 77.0 at Sta 151+27**

| Station | Discharge, cfs | Water-Surface Elevation |
|---|---|---|
| 201+00 | 14,600 | 91.5 |
| 200+50 | | 91.5 |
| 200+00 | | 91.1 |
| 199+50 | | 91.1 |
| 199+00 | | 90.9 |
| 198+50 | | 89.5 |
| 198+00 | | 88.9 |
| 197+50 | | 88.5 |
| 197+00 | | 88.2 |
| 196+50 | | 86.4 |
| 196+00 | | 87.0 |
| 195+50 | | 86.3 |
| 195+00 | | 85.6 |
| 194+50 | | 86.8 |
| 194+00 | 14,600 | 86.5 |
| 193+50 | 6,500 | 86.3 |
| 193+00 | | 86.7 |
| 192+50 | | 86.8 |
| 192+00 | | 86.8 |
| 191+50 | | 86.7 |
| 191+00 | | 86.8 |
| 190+50 | | 86.9 |
| 190+00 | | 87.1 |
| 189+50 | 6,500 | 86.9 |
| 189+00 | | 86.9 |
| 188+50 | | 86.8 |
| 188+00 | | 86.7 |

(Sheet 1 of 4)

| Table 34 (Continued) | | |
|---|---|---|
| Station | Discharge, cfs | Water-Surface Elevation |
| 187+50 | | 86.5 |
| 187+00 | | 86.3 |
| 186+50 | | 86.2 |
| 186+00 | | 86.1 |
| 185+50 | | 85.6 |
| 185+00 | | 85.5 |
| 184+50 | | 85.4 |
| 184+00 | | 85.3 |
| 183+50 | | 85.2 |
| 183+00 | | 84.6 |
| 182+50 | | 84.4 |
| 182+00 | | 84.2 |
| 181+50 | | 84.0 |
| 181+00 | | 83.8 |
| 180+50 | | 83.4 |
| 180+00 | | 83.1 |
| 179+50 | | 83.1 |
| 179+00 | | 82.9 |
| 178+50 | | 82.7 |
| 178+00 | | 82.8 |
| 177+50 | | 82.9 |
| 177+00 | | 82.1 |
| 176+50 | | 81.5 |
| 176+00 | | 81.4 |
| 175+50 | | 81.6 |
| 175+00 | | 81.7 |
| 174+50 | | 81.4 |
| 174+00 | | 81.2 |
| 173+50 | | 81.2 |
| 173+00 | | 81.2 |
| 172+50 | 6,500 | 81.2 |
| | | (Sheet 2 of 4) |

| Table 34 (Continued) | | |
|---|---|---|
| **Station** | **Discharge, cfs** | **Water-Surface Elevation** |
| 172+00 | 6,500 | 81.2 |
| 171+50 | | 81.2 |
| 171+00 | | 81.2 |
| 169+40 | | 81.3 |
| 169+00 | | 81.3 |
| 168+50 | | 81.2 |
| 168+00 | | 81.2 |
| 167+50 | 6,500 | 81.3 |
| 167+00 | 14,600 | 81.2 |
| 166+50 | | 81.1 |
| 166+00 | | 81.0 |
| 165+50 | | 80.6 |
| 165+00 | | 80.3 |
| 164+50 | | 80.3 |
| 163+00 | | 79.4 |
| 162+50 | | 79.7 |
| 162+00 | | 79.3 |
| 161+50 | | 78.6 |
| 161+00 | | 78.9 |
| 160+50 | | 77.7 |
| 160+00 | | 76.8 |
| 159+50 | | 76.6 |
| 159+00 | | 76.7 |
| 158+50 | | 76.9 |
| 158+00 | | 76.6 |
| 157+50 | | 76.8 |
| 157+00 | | 76.5 |
| 156+50 | | 76.6 |
| 156+10 | | 77.2 |
| 155+50 | | 76.8 |
| 155+00 | 14,600 | 76.7 |

| Table 34 | | |
|---|---|---|
| Station | Discharge, cfs | Water-Surface Elevation |
| 154+50 | 14,600 | 76.9 |
| 154+00 | | 77.0 |
| 153+50 | | 76.8 |
| 153+00 | | 77.0 |
| 152+50 | | 76.9 |
| 152+00 | | 76.9 |
| 151+50 | | 77.1 |
| 151+00 | 14,600 | 76.9 |

**Table 35**
**Flow Depths in the Bypass Culvert Type 18 Design Upstream Channel, Type 9 Design Bypass Entrance, Type 6 Design Pier Extensions, Fountain at Confluence, Future Conditions, Discharge at Sta 203+00 of Guadalupe River, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27 Guadalupe River**

| Sta | Depth, ft[1] | | | |
|---|---|---|---|---|
| | Left Box | | Right Box | |
| | Left Wall | Right Wall | Left Wall | Right Wall |
| 34+00 | 14.1 | 14.3 | 13.7 | 12.3 |
| 33+50 | 14.0 | 12.3 | 12.6 | 11.8 |
| 33+00 | 13.5 | 13.9 | 12.4 | 12.7 |
| 32+50 | 12.0 | 12.5 | 11.2 | 12.0 |
| 32+00 | 10.6 | 12.1 | 11.2 | 11.7 |
| 31+50 | 10.6 | 10.9 | 10.8 | 11.0 |
| 31+00 | 12.1 | 12.1 | 12.2 | 11.6 |
| 30+50 | 12.8 | 12.8 | 12.6 | 11.9 |
| 30+00 | 12.3 | 12.5 | 12.5 | 12.3 |
| 29+50 | 13.0 | 12.9 | 12.3 | 12.3 |
| 29+00 | 12.3 | 12.7 | 12.7 | 12.4 |
| 28+50 | 12.1 | 12.5 | 12.9 | 12.5 |
| 28+00 | 12.1 | 12.5 | 13.0 | 12.7 |
| 27+50 | 12.1 | 12.5 | 12.8 | 12.8 |
| 27+00 | 12.0 | 12.4 | 12.9 | 12.9 |
| 26+50 | 12.6 | 13.1 | 13.4 | 13.2 |
| 26+00 | 13.5 | 13.1 | 13.0 | 13.0 |
| 25+50 | 12.3 | 13.1 | 13.1 | 13.0 |
| 25+00 | 12.3 | 12.5 | 13.1 | 12.8 |
| 24+50 | 12.1 | 12.6 | 13.2 | 12.9 |
| 24+00 | 12.3 | 12.8 | 13.1 | 12.6 |
| 23+50 | 12.8 | 13.1 | 13.1 | 12.5 |
| 23+00 | 13.0 | 13.1 | 12.9 | 12.2 |
| 22+50 | 13.3 | 13.3 | 12.7 | 12.4 |
| 22+00 | 12.9 | 13.3 | 13.0 | 12.5 |
| 21+50 | 12.6 | 12.9 | 13.2 | 12.9 |

(Continued)

| Table 35 (Concluded) | | | | |
|---|---|---|---|---|
| | Depth, ft[1] | | | |
| | Left Box | | Right Box | |
| Sta | Left Wall | Right Wall | Left Wall | Right Wall |
| 21+00 | 12.4 | 13.0 | 13.5 | 13.3 |
| 20+50 | 12.8 | 13.3 | 13.6 | 13.0 |
| 20+00 | 13.0 | 13.2 | 13.2 | 12.9 |
| 19+50 | 13.1 | 13.4 | 13.3 | 12.9 |
| 19+00 | 12.8 | 12.8 | 13.5 | 12.4 |
| 18+50 | 14.0 | 13.8 | 14.2 | 14.0 |
| 18+00 | 14.3 | 14.2 | 14.1 | 14.0 |
| 17+00 | 14.0 | 14.2 | 14.0 | 13.9 |
| 16+50 | 13.8 | 14.1 | 14.0 | 14.0 |
| 16+00 | 13.8 | 14.0 | 14.1 | 14.0 |
| 15+50 | 13.9 | 13.9 | 14.0 | 13.9 |
| 15+00 | 14.4 | 14.0 | 14.1 | 14.1 |
| 14+50 | 14.1 | 14.1 | 14.0 | 14.2 |
| 14+00 | 14.2 | 14.1 | 14.1 | 14.2 |
| 13+50 | 14.8 | 12.0 | 14.6 | 14.3 |
| 13+00 | 14.5 | 14.5 | 14.8 | 14.6 |
| 12+50 | 14.2 | 14.5 | 14.8 | 14.6 |

**Table 36**
**Guadalupe River Water-Surface Elevations, Type 18 Design Upstream Channel, Type 11 Design Bypass Entrance, Type 6 Design Pier Extensions, Type 2 Design Left Bank Near Santa Clara Bridge, Fountain at Confluence, Future Conditions, Discharge at Sta 203+00, 9,100 cfs, Water-Surface Elevations of 73.6 at Sta 151+27**

| Sta | Discharge cfs | Elevation |
|---|---|---|
| 200+50 | 9,100 | 87.4 |
| 200+00 | | 87.4 |
| 199+50 | | 87.4 |
| 199+00 | | 87.5 |
| 198+50 | | 86.8 |
| 198+00 | | 85.5 |
| 197+50 | | 85.4 |
| 197+00 | | 85.3 |
| 196+50 | | 84.9 |
| 196+00 | | 84.4 |
| 195+50 | | 84.3 |
| 195+00 | | 83.5 |
| 194+50 | 9,100 | 85.0 |
| 194+00 | 4,120 | 84.6 |
| 193+50 | | 83.9 |
| 193+00 | | 84.1 |
| 192+50 | | 84.0 |
| 192+00 | | 84.0 |
| 191+50 | | 83.8 |
| 191+00 | | 83.9 |
| 190+50 | | 84.0 |
| 190+00 | | 84.0 |
| 189+50 | 4,120 | 84.0 |
| 189+00 | 4,120 | 83.9 |
| 188+50 | | 83.9 |
| 188+00 | | 83.7 |
| 187+50 | | 83.7 |

(Sheet 1 of 4))

| Table 36 (Continued) | | |
|---|---|---|
| Sta | Discharge cfs | Elevation |
| 187+00 | | 83.5 |
| 186+50 | | 83.4 |
| 186+00 | | 83.3 |
| 185+50 | | 83.2 |
| 185+00 | | 83.1 |
| 184+50 | | 82.8 |
| 184+00 | | 82.8 |
| 183+50 | | 82.7 |
| 183+00 | | 82.2 |
| 182+50 | | 82.1 |
| 182+00 | | 82.1 |
| 181+50 | | 81.9 |
| 181+00 | | 81.6 |
| 180+50 | | 81.1 |
| 180+00 | | 80.9 |
| 179+50 | | 80.8 |
| 179+00 | | 80.6 |
| 178+50 | | 80.5 |
| 178+00 | | 80.6 |
| 177+50 | | 80.7 |
| 177+00 | | 79.9 |
| 176+50 | | 79.0 |
| 176+00 | | 78.4 |
| 175+50 | | 78.2 |
| 175+00 | | 78.2 |
| 174+50 | | 77.6 |
| 174+00 | | 77.5 |
| 173+50 | | 77.7 |
| 173+00 | | 77.6 |
| 172+50 | 4,120 | 77.6 |
| 172+00 | 4,120 | 77.6 |

(Sheet 2 of 4)

| Table 36 (Continued) | | |
|---|---|---|
| Sta | Discharge cfs | Elevation |
| 171+50 | | 77.6 |
| 171+00 | | 77.7 |
| 169+40 | | 77.7 |
| 169+00 | | 77.8 |
| 168+50 | | 77.6 |
| 168+00 | | 77.6 |
| 167+50 | 4,120 | 77.7 |
| 167+00 | 9,100 | 77.7 |
| 166+50 | | 77.7 |
| 166+00 | | 77.4 |
| 165+50 | | 77.1 |
| 165+00 | | 76.8 |
| 164+50 | | 76.7 |
| 163+00 | | 75.7 |
| 162+50 | | 73.6 |
| 162+00 | | 75.7 |
| 161+50 | | 75.1 |
| 161+00 | | 75.4 |
| 160+50 | | 74.6 |
| 160+00 | | 73.9 |
| 159+50 | | 73.8 |
| 159+00 | | 73.4 |
| 158+50 | | 73.5 |
| 158+00 | | 73.4 |
| 157+50 | | 73.4 |
| 157+00 | | 73.2 |
| 156+50 | | 73.7 |
| 156+10 | | 73.4 |
| 155+50 | | 73.9 |
| 155+00 | 9,100 | 74.0 |
| 154+50 | 9,100 | 74.1 |

| Table 36 (Concluded) | | |
|---|---|---|
| Sta | Discharge cfs | Elevation |
| 154+00 | | 74.2 |
| 153+50 | | 74.0 |
| 153+00 | | 74.0 |
| 152+50 | | 74.1 |
| 152+00 | | 73.8 |
| 151+50 | | 73.6 |
| 151+00 | 9,100 | 73.6 |

Table 37
Flow Depths in the Bypass Culvert Type 18 Design Upstream Channel, Type 11 Design Bypass Entrance, Type 6 Design Pier Extensions, Fountain at Confluence, Future Conditions, Discharge at Sta 203+00 of Guadalupe River, 9,100 cfs, Discharge in Bypass Culvert 4,980 cfs, Water-Surface Elevation of 73.6 at Sta 151+27 Guadalupe River

| Sta | Depth, ft[1] | | | |
|---|---|---|---|---|
| | Left Box | | Right Box | |
| | Left Wall | Right Wall | Left Wall | Right Wall |
| 34+00 | 10.1 | 9.2 | 10.3 | 8.6 |
| 33+50 | 9.8 | 9.4 | 7.4 | 5.9 |
| 33+00 | 9.4 | 9.4 | 6.5 | 4.7 |
| 32+50 | 8.3 | 8.4 | 7.2 | 8.7 |
| 32+00 | 7.4 | 8.3 | 7.9 | 7.2 |
| 31+50 | 6.5 | 6.6 | 6.9 | 6.7 |
| 31+00 | 6.3 | 5.9 | 6.5 | 6.9 |
| 30+50 | 8.1 | 8.2 | 7.9 | 6.5 |
| 30+00 | 7.4 | 8.3 | 8.5 | 7.8 |
| 29+50 | 7.9 | 8.6 | 9.1 | 8.5 |
| 29+00 | 7.8 | 8.1 | 8.7 | 8.2 |
| 28+50 | 8.4 | 8.4 | 8.7 | 8.1 |
| 28+00 | 8.1 | 8.4 | 8.6 | 8.2 |
| 27+50 | 8.7 | 8.7 | 9.1 | 9.0 |
| 27+00 | 8.4 | 8.7 | 9.0 | 9.6 |
| 26+50 | 8.0 | 8.5 | 8.6 | 8.7 |
| 26+00 | 8.0 | 8.8 | 8.5 | 8.2 |
| 25+50 | 8.3 | 8.8 | 9.3 | 9.1 |
| 25+00 | 7.7 | 8.6 | 8.9 | 8.8 |
| 24+50 | 8.5 | 8.9 | 9.1 | 9.2 |
| 24+00 | 9.5 | 8.9 | 9.7 | 9.0 |
| 23+50 | 8.9 | 9.2 | 9.6 | 9.0 |
| 23+00 | 9.1 | 9.1 | 9.5 | 8.9 |
| 22+50 | 8.1 | 8.7 | 9.3 | 9.0 |
| 22+00 | 9.2 | 9.3 | 8.6 | 8.3 |
| 21+50 | 8.5 | 9.2 | 9.7 | 9.2 |

(Continued)

| Table 37 (Concluded) | | | | |
|---|---|---|---|---|
| | Depth, ft[1] | | | |
| | Left Box | | Right Box | |
| Sta | Left Wall | Right Wall | Left Wall | Right Wall |
| 21+00 | 9.1 | 9.4 | 9.5 | 9.1 |
| 20+50 | 8.3 | 9.0 | 9.3 | 9.0 |
| 20+00 | 9.2 | 9.6 | 10.0 | 9.1 |
| 19+50 | 9.5 | 9.6 | 9.2 | 9.2 |
| 19+00 | 9.0 | 9.1 | 9.6 | 8.9 |
| 18+50 | 10.3 | 10.0 | 10.5 | 9.7 |
| 18+00 | 10.5 | 10.2 | 10.2 | 10.0 |
| 17+00 | 10.2 | 9.9 | 9.9 | 10.0 |
| 16+50 | 10.1 | 10.0 | 10.0 | 10.1 |
| 16+00 | 9.9 | 10.0 | 9.8 | 10.0 |
| 15+50 | 10.1 | 10.1 | 10.0 | 10.1 |
| 15+00 | 10.1 | 10.0 | 10.4 | 10.1 |
| 14+50 | 10.2 | 10.3 | 10.3 | 10.1 |
| 14+00 | 10.4 | 10.3 | 10.5 | 10.5 |
| 13+50 | 10.9 | 10.7 | 10.7 | 10.5 |
| 13+00 | 11.1 | 11.1 | 11.3 | 10.9 |
| 12+50 | 10.5 | 10.9 | 11.0 | 10.9 |

**Table 38**
**Guadalupe River Water-Surface Elevations, Type 18 Design Upstream Channel, Type 9 Design Bypass Entrance, Type 6 Design Pier Extensions, Type 2 Design Left Bank Near Santa Clara Bridge, Fountain at Confluence, Future Conditions, Discharge at Sta 203+00, 6,500 cfs, Water-Surface Elevations of 71.9 at Sta 151+27**

| Sta | Discharge cfs | Elevation |
|---|---|---|
| 200+50 | 6,500 | 85.5 |
| 200+00 | | 85.4 |
| 199+50 | | 85.3 |
| 199+00 | | 85.3 |
| 198+50 | | 85.0 |
| 198+00 | | 83.9 |
| 197+50 | | 83.6 |
| 197+00 | | 83.6 |
| 196+50 | | 84.5 |
| 196+00 | | 82.8 |
| 195+50 | | 82.9 |
| 195+00 | | 82.9 |
| 194+50 | 6,500 | 82.9 |
| 194+00 | 3,460 | 83.2 |
| 193+50 | | 82.9 |
| 193+00 | | 82.9 |
| 192+50 | | 82.9 |
| 192+00 | | 82.8 |
| 191+50 | | 82.9 |
| 191+00 | | 83.0 |
| 190+50 | | 83.0 |
| 190+00 | | 83.1 |
| 189+50 | 3,460 | 83.1 |
| 189+00 | 3,460 | 82.9 |
| 188+50 | | 82.9 |
| 188+00 | | 82.8 |
| 187+50 | | 82.7 |

(Sheet 1 of 4))

| Table 38 (Continued) | | |
|---|---|---|
| Sta | Discharge cfs | Elevation |
| 187+00 | | 82.6 |
| 186+50 | | 82.5 |
| 186+00 | | 82.4 |
| 185+50 | | 82.3 |
| 185+00 | | 82.3 |
| 184+50 | | 82.0 |
| 184+00 | | 82.0 |
| 183+50 | | 81.9 |
| 183+00 | | 81.5 |
| 182+50 | | 81.3 |
| 182+00 | | 81.3 |
| 181+50 | | 81.1 |
| 181+00 | | 81.0 |
| 180+00 | | 80.0 |
| 179+50 | | 80.0 |
| 179+00 | | 79.9 |
| 178+50 | | 79.7 |
| 178+00 | | 79.7 |
| 177+50 | | 79.8 |
| 176+40 | | 79.1 |
| 176+00 | | 77.9 |
| 175+50 | | 76.4 |
| 175+00 | | 76.7 |
| 174+50 | | 76.3 |
| 174+00 | | 75.8 |
| 173+50 | | 75.5 |
| 173+00 | | 75.4 |
| 172+50 | 3,460 | 75.4 |
| 172+00 | 3,460 | 75.5 |
| 171+50 | | 75.5 |
| 171+00 | | 75.4 |

(Sheet 2 of 4)

| Table 38 (Continued) | | |
|---|---|---|
| Sta | Discharge cfs | Elevation |
| 160+40 | | 75.2 |
| 169+00 | | 75.5 |
| 168+50 | | 75.4 |
| 168+00 | | 75.4 |
| 167+50 | 3,460 | 75.4 |
| 167+00 | 6,500 | 75.4 |
| 166+50 | | 75.3 |
| 166+00 | | 75.1 |
| 165+50 | | 74.7 |
| 165+00 | | 74.5 |
| 164+50 | | 75.4 |
| 164+10 | | 74.2 |
| 163+00 | | 73.5 |
| 162+50 | | 73.9 |
| 162+00 | | 73.7 |
| 161+50 | | 73.5 |
| 161+00 | | 73.5 |
| 160+50 | | 72.8 |
| 160+00 | | 72.1 |
| 159+50 | | 71.8 |
| 159+00 | | 71.5 |
| 158+50 | | 71.5 |
| 158+00 | | 71.5 |
| 157+50 | | 71.3 |
| 157+00 | | 71.2 |
| 156+50 | | 71.4 |
| 156+10 | | 71.6 |
| 155+50 | | 71.9 |
| 155+00 | 6,500 | 72.1 |
| 154+50 | 6,500 | 72.1 |
| 154+00 | | 72.1 |

(Sheet 3 of 4)

| Table 38 (Concluded) | | |
|---|---|---|
| Sta | Discharge cfs | Elevation |
| 153+50 | | 71.9 |
| 153+00 | | 71.9 |
| 152+50 | | 71.9 |
| 152+00 | | 71.9 |
| 151+50 | | 72.0 |
| 151+00 | 6,500 | 71.9 |

**Table 39**
**Flow Depths in the Bypass Culvert, Type 18 Design Upstream Channel, Type 9 Design Bypass Entrance, Type 6 Design Pier Extensions, Fountain at Confluence, Future Conditions, Discharge at Sta 203+00 of Guadalupe River, 6,500 cfs, Discharge in Bypass Culvert 3,040 cfs, Water-Surface Elevation of 71.9 at Sta 151+27 Guadalupe River**

| Sta | Depth, ft[1] | | | |
|---|---|---|---|---|
| | Left Box | | Right Box | |
| | Left Wall | Right Wall | Left Wall | Right Wall |
| 34+00 | 4.5 | 4.4 | 6.4 | 2.5 |
| 33+50 | 5.9 | 5.0 | 4.9 | 4.7 |
| 33+00 | 6.8 | 6.6 | 4.9 | 5.0 |
| 32+50 | 5.9 | 6.5 | 5.4 | 5.7 |
| 32+00 | 5.5 | 6.6 | 5.4 | 5.6 |
| 31+50 | 5.1 | 4.9 | 5.1 | 4.9 |
| 31+00 | 4.8 | 4.6 | 4.3 | 3.6 |
| 30+50 | 4.6 | 4.7 | 6.1 | 5.3 |
| 30+00 | 4.7 | 5.4 | 6.1 | 5.8 |
| 29+50 | 5.6 | 6.5 | 6.1 | 5.6 |
| 29+00 | 6.4 | 6.7 | 6.4 | 5.9 |
| 28+50 | 6.0 | 6.4 | 6.3 | 5.9 |
| 28+00 | 6.2 | 6.6 | 6.2 | 5.9 |
| 27+50 | 6.6 | 6.9 | 6.8 | 6.1 |
| 27+00 | 6.4 | 6.6 | 6.5 | 6.1 |
| 26+50 | 5.8 | 6.4 | 6.3 | 6.1 |
| 26+00 | 6.3 | 6.7 | 6.5 | 6.1 |
| 25+50 | 6.1 | 6.2 | 6.1 | 5.8 |
| 25+00 | 5.9 | 6.4 | 6.4 | 6.1 |
| 24+50 | 6.3 | 6.9 | 6.8 | 6.5 |
| 24+00 | 6.5 | 7.0 | 6.8 | 6.5 |
| 23+50 | 6.8 | 7.3 | 7.1 | 6.6 |
| 23+00 | 7.0 | 7.0 | 6.9 | 6.3 |
| 22+50 | 6.4 | 6.6 | 6.9 | 6.3 |
| 22+00 | 5.9 | 6.5 | 6.9 | 6.5 |
| 21+50 | 6.3 | 6.6 | 7.0 | 6.6 |

(Continued)

| Table 39(Concluded) | | | | |
|---|---|---|---|---|
| | Depth, ft[1] | | | |
| | Left Box | | Right Box | |
| Sta | Left Wall | Right Wall | Left Wall | Right Wall |
| 21+00 | 6.7 | 6.9 | 6.9 | 6.5 |
| 20+50 | 6.6 | 7.1 | 6.8 | 6.6 |
| 20+00 | 6.6 | 7.0 | 7.2 | 6.8 |
| 19+50 | 6.6 | 7.3 | 7.5 | 7.0 |
| 19+00 | 7.1 | 7.1 | 7.6 | 6.8 |
| 18+50 | 7.8 | 8.0 | 8.1 | 7.4 |
| 18+00 | 7.9 | 7.9 | 7.9 | 7.6 |
| 17+50 | 8.0 | 7.9 | 7.8 | 7.7 |
| 17+00 | 8.0 | 7.8 | 8.0 | 7.8 |
| 16+50 | 7.8 | 7.7 | 7.8 | 7.8 |
| 16+00 | 7.4 | 7.8 | 7.9 | 7.7 |
| 15+50 | 7.9 | 8.0 | 7.9 | 8.0 |
| 15+00 | 8.0 | 8.1 | 8.0 | 7.9 |
| 14+50 | 8.1 | 8.1 | 8.2 | 8.0 |
| 14+00 | 8.1 | 8.1 | 8.3 | 8.3 |
| 13+50 | 8.6 | 8.8 | 8.6 | 8.4 |
| 13+00 | 8.8 | 8.3 | 9.0 | 8.7 |
| 12+50 | 8.3 | 8.8 | 8.8 | 8.8 |

## Table 40
## Guadalupe River and Bypass Culvert Flow Distribution for Various Modifications

| Discharge Conditions | Type Modification | Total Discharge cfs | Guadalupe River Discharge cfs | Bypass Culvert Discharge cfs | Qbc/Qt | Water-Surface Elevation Sta 199+50 |
|---|---|---|---|---|---|---|
| Future | Type 9 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 14,600 | 6,560 | 8,040 | 0.55 | 91.1 |
| Future | Type 11 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 9,100 | 4,120 | 4,980 | 0.55 | 87.4 |
| Existing | Type 9 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 9,100 | 4,050 | 5,050 | 0.55 | |
| Future | Type 9 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,500 | 3,460 | 3,040 | 0.48 | 85.3 |
| Existing | Type 9 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 6 Pier Extensions | 6,500 | 3,270 | 3,230 | 0.50 | |
| Future | Type 14 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 7 Pier Extensions | 14,600 | 6,510 | 8,090 | 0.55 | 91.5 |

Note: Manning's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel.
Qbc = Discharge in the bypass culvert.
Qt = Total discharge.

**Table 41**
**Velocities Near Pier GR1 Bent 2, Type 18 Upstream Channel, Type 9 Bypass Entrance, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 1 | 1 | 4.9 |
| 1a | 3 | 6.9 |
| 2 | 1 | 1.5 |
| 2a | 3 | 1.4 |
| 3 | 1 | 7.4 |
| 3a | 3 | 5.8 |
| 4 | 1 | 7.9 |
| 4a | 3 | 5.6 |
| 5 | 1 | 5.4 |
| 5a | 3 | 5.6 |
| 6 | 1 | 4.4 |
| 6a | 3 | 5.1 |
| 7 | 1 | 3.9 |
| 7a | 3 | 5.0 |
| 8 | 1 | 3.8 |
| 8a | 3 | 5.0 |
| 9 | 1 | 3.7 |
| 9a | 3 | 5.0 |
| 10 | 1 | 5.5 |
| 10a | 3 | 6.4 |
| 11 | 1 | 5.7 |
| 11a | 3 | 6.9 |
| 12 | 1 | 7.1 |
| 12a | 3 | 7.4 |
| 13 | 1 | 7.0 |
| 13a | 3 | 7.0 |
| 14 | 1 | 6.4 |
| 14a | 3 | 6.2 |

(Sheet 1 of 4)

| Table 41 (Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 15 | 1 | 5.3 |
| 15a | 3 | 6.1 |
| 16 | 1 | 5.7 |
| 16a | 3 | 6.8 |
| 17 | 1 | 4.4 |
| 17a | 3 | 6.1 |
| 18 | 1 | 4.5 |
| 18a | 3 | 5.5 |
| 19 | 1 | 4.7 |
| 19a | 3 | 5.3 |
| 20 | 1 | 2.7 |
| 20a | 3 | 4.0 |
| 21 | 1 | 2.1 |
| 21a | 3 | 3.5 |
| 22 | 1 | 4.0 |
| 22a | 3 | 4.5 |
| 23 | 1 | 3.4 |
| 23a | 3 | 4.4 |
| 24 | 1 | 2.4 |
| 24a | 3 | 2.9 |
| 25 | 1 | 4.5 |
| 25a | 3 | 4.8 |
| 26 | 1 | 7.7 |
| 26a | 3 | 7.9 |
| 27 | 1 | 6.1 |
| 27a | 3 | 6.1 |
| 28 | 1 | 4.3 |
| 28a | 3 | 4.7 |
| 29 | 1 | 6.0 |
| 29a | 3 | 6.3 |
| 30 | 1 | 5.1 |

(Sheet 2 of 4)

| Table 41 (Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 30a | 3 | 6.0 |
| 31 | 1 | 4.6 |
| 31a | 3 | 4.9 |
| 32 | 1 | 3.4 |
| 32a | 3 | 3.6 |
| 33 | 1 | 3.3 |
| 33a | 3 | 4.4 |
| 34 | 1 | 3.8 |
| 34a | 3 | 4.9 |
| 35 | 1 | 4.0 |
| 35a | 3 | 4.9 |
| 36 | 1 | 4.3 |
| 36a | 3 | 5.3 |
| 37 | 1 | 4.5 |
| 37a | 3 | 5.2 |
| 38 | 1 | 4.3 |
| 38a | 3 | 5.0 |
| 39 | 1 | 4.4 |
| 39a | 3 | 5.3 |
| 40 | 1 | 4.5 |
| 40a | 3 | 5.4 |
| 41 | 1 | 4.4 |
| 41a | 3 | 5.5 |
| 42 | 1 | 4.5 |
| 42a | 3 | 5.5 |
| 43 | 1 | 4.4 |
| 43a | 3 | 5.2 |
| 44 | 1 | 4.3 |
| 44a | 3 | 5.2 |
| 45 | 1 | 4.3 |
| 45a | 3 | 5.2 |
| | | (Sheet 3 of 4) |

| Table 41 (Concluded) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 46 | 1 | 4.6 |
| 46a | 3 | 5.1 |
| 47 | 1 | 4.4 |
| 47a | 3 | 5.1 |
| 48 | 1 | 3.9 |
| 48a | 3 | 5.0 |

**Table 42**
**Velocities Near Pier D Bent 15-D, Type 18 Upstream Channel, Type 9 Bypass Entrance, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 1 | 1 | 9.8 |
| 1a | 3 | 12.3 |
| 2 | 1 | 10.5 |
| 2a | 3 | 12.9 |
| 3 | 1 | 10.7 |
| 3a | 3 | 13.4 |
| 4 | 1 | 10.2 |
| 4a | 3 | 12.7 |
| 5 | 1 | 9.1 |
| 5a | 3 | 10.4 |
| 6 | 1 | 4.9 |
| 6a | 3 | 8.9 |
| 7 | 1 | 4.7 |
| 7a | 3 | 9.7 |
| 8 | 1 | 4.6 |
| 8a | 3 | 9.5 |
| 9 | 1 | 5.0 |
| 9a | 3 | 9.7 |
| 10 | 1 | 6.4 |
| 10a | 3 | 9.2 |
| 11 | 1 | 6.6 |
| 11a | 3 | 9.7 |
| 12 | 1 | 7.9 |
| 12a | 3 | 9.8 |
| 13 | 1 | 6.3 |
| 13a | 3 | 9.5 |
| 14 | 1 | 7.4 |
| 14a | 3 | 9.9 |

(Sheet 1 of 4)

**Table 42(Continued)**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 15 | 1 | 6.8 |
| 15a | 3 | 9.9 |
| 16 | 1 | 7.4 |
| 16a | 3 | 9.9 |
| 17 | 1 | 7.9 |
| 17a | 3 | 10.5 |
| 18 | 1 | 8.2 |
| 18a | 3 | 11.4 |
| 19 | 1 | 9.3 |
| 19a | 3 | 12.1 |
| 20 | 1 | 10.6 |
| 20a | 3 | 12.7 |
| 21 | 1 | 11.1 |
| 21a | 3 | 13.2 |
| 22 | 1 | 10.0 |
| 22a | 3 | 12.7 |
| 23 | 1 | 10.3 |
| 23a | 3 | 12.3 |
| 24 | 1 | 9.1 |
| 24a | 3 | 10.9 |
| 25 | 1 | 7.5 |
| 25a | 3 | 9.5 |
| 26 | 1 | 7.4 |
| 26a | 3 | 9.2 |
| 27 | 1 | 6.0 |
| 27a | 3 | 8.0 |
| 28 | 1 | 5.0 |
| 28a | 3 | 8.1 |
| 29 | 1 | 3.9 |
| 29a | 3 | 7.1 |
| 30 | 1 | 5.5 |

(Sheet 2 of 4)

| Table 42(Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 30a | 3 | 7.9 |
| 31 | 1 | 5.5 |
| 31a | 3 | 8.1 |
| 32 | 1 | 5.7 |
| 32a | 3 | 9.1 |
| 33 | 1 | 3.7 |
| 33a | 3 | 6.8 |
| 34 | 1 | 1.0 |
| 34a | 3 | 1.2 |
| 35 | 1 | 1.3 |
| 35a | 3 | 1.3 |
| 36 | 1 | 2.1 |
| 36a | 3 | 1.8 |
| 37 | 1 | 12.4 |
| 37a | 3 | 13.4 |
| 38 | 1 | 13.5 |
| 38a | 3 | 13.9 |
| 39 | 1 | 13.5 |
| 39a | 3 | 13.9 |
| 40 | 1 | 10.4 |
| 40a | 3 | 11.7 |
| 41 | 1 | 8.9 |
| 41a | 3 | 10.4 |
| 42 | 1 | 6.7 |
| 42a | 3 | 8.7 |
| 43 | 1 | 6.8 |
| 43a | 3 | 8.3 |
| 44 | 1 | 5.7 |
| 44a | 3 | 8.6 |
| 45 | 1 | 6.9 |
| 45a | 3 | 9.2 |

(Sheet 3 of 4)

| Table 42(Concluded) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 46 | 1 | 6.9 |
| 46a | 3 | 9.5 |
| 47 | 1 | 7.6 |
| 47a | 3 | 9.6 |
| 48 | 1 | 6.7 |
| 48a | 3 | 9.5 |
| 49 | 1 | 4.9 |
| 49a | 3 | 7.3 |
| 50 | 1 | 6.0 |
| 50a | 3 | 6.4 |
| 51 | 1 | 6.0 |
| 51a | 3 | 8.7 |
| 52 | 1 | 7.0 |
| 52a | 3 | 9.3 |
| 53 | 1 | 7.8 |
| 53a | 3 | 10.2 |
| 54 | 1 | 8.5 |
| 54a | 3 | 11.0 |
| 55 | 1 | 10.7 |
| 55a | 3 | 12.0 |

**Table 43**
**Velocities Near Pier GR1 Bent 2, Type 18 Upstream Channel, Type 9 Bypass Entrance, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 1 | 1 | 4.9 |
| 1a | 3 | 6.9 |
| 2 | 1 | 1.5 |
| 2a | 3 | 1.4 |
| 3 | 1 | 7.4 |
| 3a | 3 | 5.8 |
| 4 | 1 | 7.9 |
| 4a | 3 | 5.6 |
| 5 | 1 | 5.4 |
| 5a | 3 | 5.6 |
| 6 | 1 | 4.4 |
| 6a | 3 | 5.1 |
| 7 | 1 | 3.9 |
| 7a | 3 | 5.0 |
| 22 | 1 | 3.8 |
| 22a | 3 | 5.0 |
| 23 | 1 | 3.7 |
| 23a | 3 | 5.0 |
| 24 | 1 | 5.5 |
| 24a | 3 | 6.4 |
| 25 | 1 | 5.7 |
| 25a | 3 | 6.9 |
| 26 | 1 | 7.1 |
| 26a | 3 | 7.4 |
| 27 | 1 | 7.0 |
| 27a | 3 | 7.0 |
| 28 | 1 | 6.4 |
| 28a | 3 | 6.2 |

(Sheet 1 of 3)

| Table 43(Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 29 | 1 | 5.3 |
| 29a | 3 | 6.1 |
| 30 | 1 | 5.7 |
| 30a | 3 | 6.8 |
| 31 | 1 | 4.4 |
| 31a | 3 | 6.1 |
| 32 | 1 | 4.5 |
| 32a | 3 | 5.5 |
| 33 | 1 | 4.7 |
| 33a | 3 | 5.3 |
| 34 | 1 | 2.7 |
| 34a | 3 | 4.0 |
| 35 | 1 | 2.1 |
| 35a | 3 | 3.5 |
| 36 | 1 | 4.0 |
| 36a | 3 | 4.5 |
| 37 | 1 | 3.4 |
| 37a | 3 | 4.4 |
| 38 | 1 | 2.4 |
| 38a | 3 | 2.9 |
| 39 | 1 | 4.5 |
| 39a | 3 | 4.8 |
| 40 | 1 | 7.7 |
| 40a | 3 | 7.9 |
| 41 | 1 | 6.1 |
| 41a | 3 | 6.1 |
| 42 | 1 | 4.3 |
| 42a | 3 | 4.7 |
| 43 | 1 | 6.0 |
| 43a | 3 | 6.3 |
| 44 | 1 | 5.1 |
| | | (Sheet 2 of 3 ) |

| Table 43(Concluded) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 44a | 3 | 6.0 |
| 45 | 1 | 4.6 |
| 45a | 3 | 4.9 |
| 46 | 1 | 3.4 |
| 46a | 3 | 3.6 |
| 47 | 1 | 3.3 |
| 47a | 3 | 4.4 |
| 48 | 1 | 3.8 |
| 48a | 3 | 7.2 |

Table 44
Velocities Near Pier D Bent 15-D, Type 18 Upstream Channel, Type 9 Bypass Entrance, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 1 | 1 | 10.3 |
| 1a | 3 | 14.9 |
| 2 | 1 | 7.5 |
| 2a | 3 | 13.7 |
| 3 | 1 | 4.9 |
| 3a | 3 | 11.0 |
| 4 | 1 | 2.4 |
| 4a | 3 | 9.6 |
| 5 | 1 | 11.3 |
| 5a | 3 | 13.6 |
| 6 | 1 | 8.2 |
| 6a | 3 | 10.9 |
| 7 | 1 | 9.6 |
| 7a | 3 | 10.9 |
| 8 | 1 | 7.8 |
| 8a | 3 | 10.1 |
| 9 | 1 | 7.2 |
| 9a | 3 | 8.7 |
| 10 | 1 | 7.0 |
| 10a | 3 | 6.1 |
| 11 | 1 | 6.5 |
| 11a | 3 | 9.5 |
| 12 | 1 | 8.3 |
| 12a | 3 | 10.1 |
| 13 | 1 | 8.7 |
| 13a | 3 | 10.1 |
| 14 | 1 | 8.0 |
| 14a | 3 | 9.6 |

(Sheet 1 of 5)

| Table 44(Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 15 | 1 | 8.8 |
| 15a | 3 | 10.2 |
| 16 | 1 | 9.8 |
| 16a | 3 | 11.3 |
| 17 | 1 | 12.0 |
| 17a | 3 | 12.9 |
| 18 | 1 | 12.8 |
| 18a | 3 | 13.8 |
| 19 | 1 | 12.9 |
| 19a | 3 | 13.9 |
| 20 | 1 | 12.3 |
| 20a | 3 | 13.6 |
| 21 | 1 | 11.8 |
| 21a | 3 | 12.6 |
| 22 | 1 | 12.3 |
| 22a | 3 | 13.0 |
| 23 | 1 | 13.0 |
| 23a | 3 | 13.8 |
| 24 | 1 | 12.9 |
| 24a | 3 | 13.9 |
| 25 | 1 | 12.4 |
| 25a | 3 | 12.7 |
| 26 | 1 | 11.6 |
| 26a | 3 | 11.8 |
| 27 | 1 | 11.4 |
| 27a | 3 | 11.6 |
| 28 | 1 | 9.9 |
| 28a | 3 | 11.2 |
| 29 | 1 | 9.5 |
| 29a | 3 | 10.6 |
| 30 | 1 | 10.4 |
| | | (Sheet 2 of 5) |

| Table 44(Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 30a | 3 | 11.2 |
| 31 | 1 | 10.0 |
| 31a | 3 | 11.2 |
| 32 | 1 | 7.0 |
| 32a | 3 | 9.6 |
| 33 | 1 | 6.7 |
| 33a | 3 | 9.2 |
| 34 | 1 | 2.6 |
| 34a | 3 | 2.3 |
| 35 | 1 | 1.9 |
| 35a | 3 | 2.8 |
| 36 | 1 | 6.3 |
| 36a | 3 | 7.3 |
| 37 | 1 | 5.8 |
| 37a | 3 | 9.4 |
| 38 | 1 | 4.4 |
| 38a | 3 | 11.9 |
| 39 | 1 | 10.0 |
| 39a | 3 | 14.2 |
| 40 | 1 | 10.4 |
| 40a | 3 | 12.4 |
| 41 | 1 | 8.3 |
| 41a | 3 | 10.3 |
| 42 | 1 | 7.2 |
| 42a | 3 | 9.7 |
| 43 | 1 | 5.7 |
| 43a | 3 | 8.4 |
| 44 | 1 | 6.2 |
| 44a | 3 | 8.9 |
| 45 | 1 | 5.7 |
| 45a | 3 | 8.8 |
| | | (Sheet 3 of 5) |

| Table 44(Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 46 | 1 | 6.7 |
| 46a | 3 | 9.5 |
| 47 | 1 | 6.5 |
| 47a | 3 | 9.7 |
| 48 | 1 | 69.5 |
| 48a | 3 | 9.7 |
| 49 | 1 | 7.1 |
| 49a | 3 | 9.8 |
| 50 | 1 | 7.8 |
| 50a | 3 | 10.4 |
| 51 | 1 | 9.1 |
| 51a | 3 | 11.1 |
| 52 | 1 | 9.8 |
| 52a | 3 | 12.0 |
| 53 | 1 | 10.7 |
| 53a | 3 | 12.7 |
| 54 | 1 | 11.4 |
| 54a | 3 | 12.8 |
| 55 | 1 | 10.3 |
| 55a | 3 | 12.4 |
| 56 | 1 | 8.9 |
| 56a | 3 | 2.9 |
| 57 | 1 | 8.6 |
| 57a | 3 | 11.3 |
| 58 | 1 | 9.3 |
| 58a | 3 | 11.7 |
| 59 | 1 | 9.8 |
| 59a | 3 | 11.9 |
| 60 | 1 | 9.3 |
| 60a | 3 | 11.5 |
| 61 | 1 | 9.2 |
| | | (Sheet 4 of 5) |

| Table 44(Concluded) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 61a | 3 | 11.3 |
| 62 | 1 | 8.6 |
| 62a | 3 | 11.0 |
| 63 | 1 | 8.7 |
| 63a | 3 | 10.5 |
| 64 | 1 | 8.0 |
| 64a | 3 | 10.1 |
| 65 | 1 | 8.2 |
| 65a | 3 | 10.0 |
| 66 | 1 | 8.1 |
| 66a | 3 | 10.0 |

| Table 45<br>Velocities Near Pier D Bent 15-C, Type 18 Upstream Channel, Type 9 Bypass Entrance, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27 | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 1 | 1 | 14.9 |
| 1a | 3 | 16.9 |
| 2 | 1 | 11.8 |
| 2a | 3 | 15.6 |
| 3 | 1 | 8.0 |
| 3a | 3 | 13.0 |
| 4 | 1 | 6.3 |
| 4a | 3 | 11.0 |
| 5 | 1 | 11.2 |
| 5a | 3 | 13.3 |
| 6 | 1 | 7.9 |
| 6a | 3 | 10.4 |
| 7 | 1 | 9.2 |
| 7a | 3 | 11.0 |
| 8 | 1 | 7.3 |
| 8a | 3 | 10.3 |
| 9 | 1 | 8.8 |
| 9a | 3 | 10.5 |
| 10 | 1 | 9.7 |
| 10a | 3 | 12.5 |
| 11 | 1 | 13.0 |
| 11a | 3 | 14.9 |
| 12 | 1 | 11.3 |
| 12a | 3 | 14.3 |
| 13 | 1 | 10.1 |
| 13a | 3 | 13.9 |
| 14 | 1 | 8.7 |
| 14a | 3 | 13.4 |

(Sheet 1 of 4)

| Table 45 (Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 15 | 1 | 13.3 |
| 15a | 3 | 14.5 |
| 16 | 1 | 13.8 |
| 16a | 3 | 14.8 |
| 17 | 1 | 13.6 |
| 17a | 3 | 14.5 |
| 18 | 1 | 12.9 |
| 18a | 3 | 14.0 |
| 19 | 1 | 12.3 |
| 19a | 3 | 13.4 |
| 20 | 1 | 11.3 |
| 20a | 3 | 12.7 |
| 21 | 1 | 10.5 |
| 21a | 3 | 11.9 |
| 22 | 1 | 8.9 |
| 22a | 3 | 11.7 |
| 23 | 1 | 8.9 |
| 23a | 3 | 11.2 |
| 24 | 1 | 7.5 |
| 24a | 3 | 8.5 |
| 25 | 1 | 2.6 |
| 25a | 3 | 2.9 |
| 26 | 1 | 3.6 |
| 26a | 3 | 6.9 |
| 27 | 1 | 6.0 |
| 27a | 3 | 9.6 |
| 28 | 1 | 10.5 |
| 28a | 3 | 13.5 |
| 29 | 1 | 8.0 |
| 29a | 3 | 14.6 |
| 30 | 1 | 13.5 |

(Sheet 2 of 4)

| Table 45 (Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 30a | 3 | 16.8 |
| 31 | 1 | 12.8 |
| 31a | 3 | 14.7 |
| 32 | 1 | 11.3 |
| 32a | 3 | 13.2 |
| 33 | 1 | 9.1 |
| 33a | 3 | 11.4 |
| 34 | 1 | 8.6 |
| 34a | 3 | 12.2 |
| 35 | 1 | 9.7 |
| 35a | 3 | 12.5 |
| 36 | 1 | 9.7 |
| 36a | 3 | 12.1 |
| 37 | 1 | 11.8 |
| 37a | 3 | 13.6 |
| 38 | 1 | 11.9 |
| 38a | 3 | 14.2 |
| 39 | 1 | 12.4 |
| 39a | 3 | 15.1 |
| 40 | 1 | 12.5 |
| 40a | 3 | 14.6 |
| 41 | 1 | 11.5 |
| 41a | 3 | 13.9 |
| 42 | 1 | 12.2 |
| 42a | 3 | 13.7 |
| 43 | 1 | 11.8 |
| 43a | 3 | 13.9 |
| 44 | 1 | 11.4 |
| 44a | 3 | 13.4 |
| 45 | 1 | 11.1 |
| 45a | 3 | 12.7 |

(Sheet 3 of 4)

Table 45 (Concluded)

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 46 | 1 | 10.8 |
| 46a | 3 | 12.5 |
| 47 | 1 | 9.4 |
| 47a | 3 | 12.0 |
| 48 | 1 | 8.7 |
| 48a | 3 | 11.8 |

Table 46
Velocities Near Pier D Bent 15-C, Type 18 Upstream Channel, Type 9 Bypass Entrance, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 1 | 0 | 16.0 |
| 1a | 3 | 17.7 |
| 2 | 1 | 13.4 |
| 2a | 3 | 15.2 |
| 3 | 1 | 7.9 |
| 3a | 3 | 13.0 |
| 4 | 1 | 6.2 |
| 4a | 3 | 9.4 |
| 5 | 1 | 10.5 |
| 5a | 3 | 13.1 |
| 6 | 1 | 8.5 |
| 6a | 3 | 11.3 |
| 7 | 1 | 8.6 |
| 7a | 3 | 11.6 |
| 8 | 1 | 7.0 |
| 8a | 3 | 9.1 |
| 9 | 1 | 8.5 |
| 9a | 3 | 9.4 |
| 10 | 1 | 9.3 |
| 10a | 3 | 11.4 |
| 11 | 1 | 11.1 |
| 11a | 3 | 13.2 |
| 12 | 1 | 11.0 |
| 12a | 3 | 14.2 |
| 13 | 1 | 8.5 |
| 13a | 3 | 13.3 |
| 14 | 1 | 7.9 |
| 14a | 3 | 11.3 |

(Sheet 1 of 4)

**Table 46 (Continued)**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 15 | 1 | 8.3 |
| 15a | 3 | 9.7 |
| 16 | 1 | 8.2 |
| 16a | 3 | 9.7 |
| 17 | 1 | 7.9 |
| 17a | 3 | 9.8 |
| 18 | 1 | 8.1 |
| 18a | 3 | 10.1 |
| 19 | 1 | 8.3 |
| 19a | 3 | 10.5 |
| 20 | 1 | 7.1 |
| 20a | 3 | 9.2 |
| 21 | 1 | 6.8 |
| 21a | 3 | 8.6 |
| 22 | 1 | 8.0 |
| 22a | 3 | 11.0 |
| 23 | 1 | 6.9 |
| 23a | 3 | 10.6 |
| 24 | 1 | 6.5 |
| 24a | 3 | 7.5 |
| 25 | 1 | 7.6 |
| 25a | 3 | 4.9 |
| 26 | 1 | 1.5 |
| 26a | 3 | 9.4 |
| 27 | 1 | 2.4 |
| 27a | 3 | 10.6 |
| 28 | 1 | 7.7 |
| 28a | 3 | 12.6 |
| 29 | 1 | 7.0 |
| 29a | 3 | 13.8 |
| 30 | 1 | 8.6 |

(Sheet 2 of 4)

| Table 46 (Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 30a | 3 | 14.5 |
| 31 | 1 | 14.2 |
| 31a | 3 | 16.5 |
| 32 | 1 | 11.2 |
| 32a | 3 | 14.0 |
| 33 | 1 | 8.0 |
| 33a | 3 | 11.4 |
| 34 | 1 | 9.3 |
| 34a | 3 | 12.2 |
| 35 | 1 | 9.2 |
| 35a | 3 | 12.2 |
| 36 | 1 | 9.2 |
| 36a | 3 | 12.1 |
| 37 | 1 | 10.1 |
| 37a | 3 | 13.1 |
| 38 | 1 | 11.4 |
| 38a | 3 | 13.9 |
| 39 | 1 | 11.0 |
| 39a | 3 | 13.8 |
| 40 | 1 | 11.3 |
| 40a | 3 | 14.0 |
| 41 | 1 | 9.8 |
| 41a | 3 | 13.1 |
| 42 | 1 | 10.7 |
| 42a | 3 | 13.3 |
| 43 | 1 | 10.6 |
| 43a | 3 | 13.0 |
| 44 | 1 | 11.4 |
| 44a | 3 | 13.7 |
| 45 | 1 | 10.4 |
| 45a | 3 | 12.8 |

(Sheet 3 of 4)

| Table 46 (Concluded) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 46 | 1 | 9.6 |
| 46a | 3 | 12.5 |
| 47 | 1 | 9.7 |
| 47a | 3 | 12.8 |
| 48 | 1 | 9.0 |
| 48a | 3 | 12.3 |

**Table 47**
**Velocities Near Pier D Bent 15-A, Type 18 Upstream Channel, Type 9 Bypass Entrance, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 1 | 1.0 | 13.6 |
| 1a | 3.0 | 14.4 |
| 2 | 1.0 | 12.8 |
| 2a | 3.0 | 12.8 |
| 3 | 1.0 | 10.8 |
| 3a | 3.0 | 12.8 |
| 4 | 1.0 | 10.8 |
| 4a | 3.0 | 11.6 |
| 5 | 1.0 | 10.4 |
| 5a | 3.0 | 10.6 |
| 6 | 1.0 | 8.7 |
| 6a | 3.0 | 9.5 |
| 7 | 1.0 | 9.4 |
| 7a | 3.0 | 10.5 |
| 8 | 1.0 | 10.6 |
| 8a | 3.0 | 10.7 |
| 9 | 1.0 | 10.2 |
| 9a | 3.0 | 10.5 |
| 10 | 1.0 | 11.4 |
| 10a | 3.0 | 11.5 |
| 11 | 1.0 | 12.7 |
| 11a | 3.0 | 12.9 |
| 12 | 1.0 | 13.2 |
| 12a | 3.0 | 13.7 |
| 13 | 1.0 | 9.7 |
| 13a | 3.0 | 11.9 |
| 14 | 1.0 | 11.8 |
| 14a | 3.0 | 12.5 |

(Sheet 1 of 4)

| Table 47 (Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 15 | 1.0 | 9.3 |
| 15a | 3.0 | 10.8 |
| 16 | 1.0 | 8.7 |
| 16a | 3.0 | 10.6 |
| 17 | 1.0 | 9.3 |
| 17a | 3.0 | 10.8 |
| 18 | 1.0 | 8.0 |
| 18a | 3.0 | 10.1 |
| 19 | 1.0 | 7.0 |
| 19a | 3.0 | 8.6 |
| 20 | 1.0 | 6.6 |
| 20a | 3.0 | 8.0 |
| 21 | 1.0 | 7.2 |
| 21a | 3.0 | 10.3 |
| 22 | 1.0 | 6.3 |
| 22a | 3.0 | 10.1 |
| 23 | 1.0 | 8.0 |
| 23a | 3.0 | 10.2 |
| 24 | 1.0 | 5.4 |
| 24a | 3.0 | 7.1 |
| 25 | 1.0 | 0.8 |
| 25a | 3.0 | 1.5 |
| 26 | 1.0 | 3.1 |
| 26a | 3.0 | 8.1 |
| 27 | 1.0 | 5.3 |
| 27a | 3.0 | 10.0 |
| 28 | 1.0 | 8.2 |
| 28a | 3.0 | 10.8 |
| 29 | 1.0 | 7.8 |
| 29a | 3.0 | 14.4 |
| 30 | 1.0 | 11.7 |

(Sheet 2 of 4)

| Table 47 (Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 30a | 3.0 | 15.3 |
| 31 | 1.0 | 11.8 |
| 31a | 3.0 | 14.6 |
| 32 | 1.0 | 10.0 |
| 32a | 3.0 | 13.0 |
| 33 | 1.0 | 8.2 |
| 33a | 3.0 | 11.6 |
| 34 | 1.0 | 7.3 |
| 34a | 3.0 | 12.1 |
| 35 | 1.0 | 5.6 |
| 35a | 3.0 | 10.0 |
| 36 | 1.0 | 6.6 |
| 36a | 3.0 | 9.8 |
| 37 | 1.0 | 7.1 |
| 37a | 3.0 | 11.0 |
| 38 | 1.0 | 8.0 |
| 38a | 3.0 | 10.0 |
| 39 | 1.0 | 6.9 |
| 39a | 3.0 | 9.6 |
| 40 | 1.0 | 8.1 |
| 40a | 3.0 | 14.0 |
| 41 | 1.0 | 6.8 |
| 41a | 3.0 | 13.6 |
| 42 | 1.0 | 12.0 |
| 42a | 3.0 | 15.3 |
| 43 | 1.0 | 12.3 |
| 43a | 3.0 | 15.4 |
| 44 | 1.0 | 12.5 |
| 44a | 3.0 | 15.1 |
| 45 | 1.0 | 11.6 |
| 45a | 3.0 | 14.7 |

(Sheet 3 of 4)

**Table 47 (Concluded)**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 46 | 1.0 | 11.8 |
| 46a | 3.0 | 14.7 |
| 47 | 1.0 | 11.1 |
| 47a | 3.0 | 14.4 |
| 48 | 1.0 | 10.1 |
| 48a | 3.0 | 13.1 |

**Table 48**
**Velocities Near Pier GR 5 Bent 15, Type 18 Upstream Channel, Type 9 Bypass Entrance, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 1 | 1 | 12.9 |
| 1a | 3 | 12.9 |
| 2 | 1 | 11.5 |
| 2a | 3 | 12.5 |
| 3 | 1 | 10.9 |
| 3a | 3 | 11.5 |
| 4 | 1 | 10.1 |
| 4a | 3 | 1.7 |
| 5 | 1 | 8.1 |
| 5a | 3 | 8.9 |
| 6 | 1 | 6.8 |
| 6a | 3 | 7.3 |
| 7 | 1 | 6.0 |
| 7a | 3 | 6.6 |
| 8 | 1 | 5.6 |
| 8a | 3 | 6.3 |
| 9 | 1 | 5.1 |
| 9a | 3 | 5.4 |
| 10 | 1 | 5.7 |
| 10a | 3 | 6.0 |
| 11 | 1 | 6.1 |
| 11a | 3 | 6.3 |
| 12 | 1 | 5.6 |
| 12a | 3 | 6.3 |
| 13 | 1 | 5.7 |
| 13a | 3 | 6.6 |
| 14 | 1 | 5.3 |
| 14a | 3 | 6.0 |

(Sheet 1 of 4)

| Table 48(Continued) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 15 | 1 | 5.9 |
| 15a | 3 | 6.7 |
| 16 | 1 | 6.3 |
| 16a | 3 | 7.4 |
| 17 | 1 | 7.9 |
| 17a | 3 | 8.6 |
| 18 | 1 | 9.7 |
| 18a | 3 | 10.2 |
| 19 | 1 | 10.4 |
| 19a | 3 | 10.6 |
| 20 | 1 | 10.5 |
| 20a | 3 | 10.6 |
| 21 | 1 | 10.5 |
| 21a | 3 | 10.8 |
| 22 | 1 | 10.4 |
| 22a | 3 | 10.9 |
| 23 | 1 | 10.5 |
| 23a | 3 | 10.9 |
| 24 | 1 | 10.2 |
| 24a | 3 | 10.3 |
| 25 | 1 | 8.9 |
| 25a | 3 | 10.0 |
| 26 | 1 | 7.5 |
| 26a | 3 | 9.2 |
| 27 | 1 | 6.7 |
| 27a | 3 | 7.9 |
| 28 | 1 | 6.4 |
| 28a | 3 | 7.6 |
| 29 | 1 | 4.8 |
| 29a | 3 | 5.8 |
| 30 | 1 | 5.1 |

**Table 48(Continued)**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 30a | 3 | 6.2 |
| 31 | 1 | 4.9 |
| 31a | 3 | 6.3 |
| 32 | 1 | 5.9 |
| 32a | 3 | 6.4 |
| 33 | 1 | 6.2 |
| 33a | 3 | 6.5 |
| 34 | 1 | 1.7 |
| 34a | 3 | 1.8 |
| 35 | 1 | 2.1 |
| 35a | 3 | 2.5 |
| 36 | 1 | 2.0 |
| 36a | 3 | 3.4 |
| 37 | 1 | 3.5 |
| 37a | 3 | 7.3 |
| 38 | 1 | 3.2 |
| 38a | 3 | 8.7 |
| 39 | 1 | 4.1 |
| 39a | 3 | 9.9 |
| 40 | 1 | 9.9 |
| 40a | 3 | 14.3 |
| 41 | 1 | 13.6 |
| 41a | 3 | 9.5 |
| 42 | 1 | 11.5 |
| 42a | 3 | 13.2 |
| 43 | 1 | 11.4 |
| 43a | 3 | 12.4 |
| 44 | 1 | 9.1 |
| 44a | 3 | 9.3 |
| 45 | 1 | 6.8 |
| 45a | 3 | 7.2 |

| Table 48(Concluded) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 46 | 1 | 5.9 |
| 46a | 3 | 6.5 |
| 47 | 1 | 6.7 |
| 47a | 3 | 6.8 |
| 48 | 1 | 6.8 |
| 48a | 3 | 7.0 |
| 49 | 1 | 8.0 |
| 49a | 3 | 8.4 |
| 50 | 1 | 10.6 |
| 50a | 3 | 10.7 |
| 51 | 1 | 12.5 |
| 51a | 3 | 12.6 |
| 52 | 1 | 12.7 |
| 52a | 3 | 12.7 |
| 53 | 1 | 12.6 |
| 53a | 3 | 12.6 |
| 54 | 1 | 12.1 |
| 54a | 3 | 12.3 |

**Table 49**
**Velocities Near Pier GD3 Bent 7, Type 18 Upstream Channel, Type 9 Bypass Entrance, Future Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 1 | 1 | 11.7 |
| 1a | 3 | 12.2 |
| 2 | 1 | 10.7 |
| 2a | 3 | 11.2 |
| 3 | 1 | 8.9 |
| 3a | 3 | 11.1 |
| 4 | 1 | 9.9 |
| 4a | 3 | 10.3 |
| 5 | 1 | 11.9 |
| 5a | 3 | 12.1 |
| 6 | 1 | 8.1 |
| 6a | 3 | 8.4 |
| 7 | 1 | 6.5 |
| 7a | 3 | 7.2 |
| 8 | 1 | 6.1 |
| 8a | 3 | 7.5 |
| 9 | 1 | 5.3 |
| 9a | 3 | 5.7 |
| 10 | 1 | 5.3 |
| 10a | 3 | 7.1 |
| 11 | 1 | 6.2 |
| 11a | 3 | 7.9 |
| 12 | 1 | 5.8 |
| 12a | 3 | 7.2 |
| 13 | 1 | 5.7 |
| 13a | 3 | 7.2 |
| 14 | 1 | 5.2 |
| 14a | 3 | 6.8 |

(Sheet 1 of 5)

**Table 49(Continued)**

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 15 | 1 | 5.4 |
| 15a | 3 | 6.9 |
| 16 | 1 | 7.6 |
| 16a | 3 | 8.9 |
| 17 | 1 | 8.9 |
| 17a | 3 | 9.8 |
| 18 | 1 | 9.6 |
| 18a | 3 | 10.5 |
| 19 | 1 | 10.3 |
| 19a | 3 | 11.0 |
| 20 | 1 | 10.0 |
| 20a | 3 | 11.3 |
| 21 | 1 | 8.8 |
| 21a | 3 | 10.6 |
| 22 | 1 | 8.4 |
| 22a | 3 | 10.5 |
| 23 | 1 | 8.9 |
| 23a | 3 | 10.9 |
| 24 | 1 | 9.1 |
| 24a | 3 | 10.4 |
| 25 | 1 | 9.2 |
| 25a | 3 | 10.3 |
| 26 | 1 | 8.4 |
| 26a | 3 | 9.8 |
| 27 | 1 | 8.0 |
| 27a | 3 | 9.2 |
| 28 | 1 | 6.0 |
| 28a | 3 | 8.3 |
| 29 | 1 | 6.2 |
| 29a | 3 | 8.0 |
| 30 | 1 | 6.0 |

(Sheet 2 of 5)

Table 49(Continued)

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 30a | 3 | 7.5 |
| 31 | 1 | 5.6 |
| 31a | 3 | 7.8 |
| 32 | 1 | 7.0 |
| 32a | 3 | 8.3 |
| 33 | 1 | 5.4 |
| 33a | 3 | 7.0 |
| 34 | 1 | 1.8 |
| 34a | 3 | 1.9 |
| 35 | 1 | 1.6 |
| 35a | 3 | 1.8 |
| 36 | 1 | 1.7 |
| 36a | 3 | 1.9 |
| 37 | 1 | 5.6 |
| 37a | 3 | 5.7 |
| 38 | 1 | 2.7 |
| 38a | 3 | 8.8 |
| 39 | 1 | 5.8 |
| 39a | 3 | 11.5 |
| 40 | 1 | 8.2 |
| 40a | 3 | 12.6 |
| 41 | 1 | 9.1 |
| 41a | 3 | 12.0 |
| 42 | 1 | 8.3 |
| 42a | 3 | 11.0 |
| 43 | 1 | 9.0 |
| 43a | 3 | 10.2 |
| 44 | 1 | 8.0 |
| 44a | 3 | 8.9 |
| 45 | 1 | 5.9 |
| 45a | 3 | 6.9 |

(Sheet 3 of 5)

## Table 49(Continued)

| Station | Distance Off Botton ft | Average Velocity ft/sec |
|---|---|---|
| 46 | 1 | 6.1 |
| 46a | 3 | 7.5 |
| 47 | 1 | 6.4 |
| 47a | 3 | 8.7 |
| 48 | 1 | 7.2 |
| 48a | 3 | 9.1 |
| 49 | 1 | 7.4 |
| 49a | 3 | 8.8 |
| 50 | 1 | 9.5 |
| 50a | 3 | 10.5 |
| 51 | 1 | 10.0 |
| 51a | 3 | 11.2 |
| 52 | 1 | 8.7 |
| 52a | 3 | 10.9 |
| 53 | 1 | 8.7 |
| 53a | 3 | 10.8 |
| 54 | 1 | 7.8 |
| 54a | 3 | 10.7 |
| 55 | 1 | 7.0 |
| 55a | 3 | 10.5 |
| 56 | 1 | 5.5 |
| 56a | 3 | 10.0 |
| 57 | 1 | 8.5 |
| 57a | 3 | 10.9 |
| 58 | 1 | 6.9 |
| 58a | 3 | 9.5 |
| 59 | 1 | 10.2 |
| 59a | 3 | 11.7 |
| 60 | 1 | 9.3 |
| 60a | 3 | 10.8 |
| 61 | 1 | 9.7 |

(Sheet 4 of 5)

| Table 49(Concluded) | | |
|---|---|---|
| Station | Distance Off Botton ft | Average Velocity ft/sec |
| 61a | 3 | 11.2 |
| 62 | 1 | 9.1 |
| 62a | 3 | 10.7 |
| 63 | 1 | 8.0 |
| 63a | 3 | 10.0 |
| 64 | 1 | 8.6 |
| 64a | 3 | 9.6 |
| 65 | 1 | 7.7 |
| 65a | 3 | 9.1 |
| 66 | 1 | 7.5 |
| 66a | 3 | 8.9 |

**Table 50**
**Explanation of Pier Extension Information**

| PIER ID | W in ft | R in ft |
|---|---|---|
| GR1 BENT 4 | 5.0 | 1 |
| NEW PIER | 5.0 | 1 |
| GR5 BENT 15 | 5.0 | 1 |
| GD3 BENT 7 | 5.0 | 1 |
| D BENT 15-D | 5.0 | 1 |
| GR8 BENT 21 | 5.0 | 1 |
| GD4 BENT 12 | 5.0 | 1 |
| GVC BENT 5A | 13.00 | 2 |
| GRV BENT 3B | 13.00 | 2 |

**Table 51**
**Guadalupe River Water-Surface Elevations, Type 18 Upstream Channel, Type 7 Pier Extensions, Type 14 Bypass Entrance, Future Conditions, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Water-Surface Elevation |
|---|---|---|
| 200+50 | 14,600 | 91.8 |
| 200+00 | | 91.5 |
| 199+50 | | 91.5 |
| 199+00 | | 91.3 |
| 198+50 | | 89.8 |
| 198+00 | | 89.2 |
| 197+50 | | 89.3 |
| 197+00 | | 88.7 |
| 196+50 | | 87.1 |
| 196+00 | | 87.1 |
| 195+50 | | 87.0 |
| 195+00 | | 86.5 |
| 194+50 | | 87.7 |
| 194+00 | | 87.0 |
| 193+50 | 6,500 | 87.0 |
| 193+00 | | 87.2 |
| 192+50 | | 87.2 |
| 192+00 | | 87.1 |

**Table 52**

**Guadalupe River and Bypass Culvert Flow Distribution for Various Modifications**

| Discharge Conditions | Type Modification | Total Discharge cfs | Guadalupe River Discharge cfs | Bypass Culvert Discharge cfs | Obc/QT |
|---|---|---|---|---|---|
| Future | Type 14 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 7 Pier Extensions<br>Sediment in Upstream Channel | 14,600 | 6,510 | 8,090 | 0.55 |
| Future | Type 14 Bypass Entrance<br>Type 18 Upstream Channel<br>Sediment in Upstream Channel | 14,600 | 6,700 | 7,900 | 0.54 |
| Future | Type 14 Bypass Entrance<br>Type 18 Upstream Channel<br>Type 7 Pier Extensions<br>Water-Surface Elevation<br>at Woz Way Raised 2 ft | 14,600 | 5,630 | 8,970 | 0.61 |

Note: Manning's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel.
Obc = Discharge in the bypass culvert.
Qt = Total discharge.

z

**Table 53**

**Guadalupe River Water-Surface Elevations, Type 19 Upstream Channel, Type 16 Bypass Entrance, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+27**

| Sta | Discharge cfs | Future Conditions Water-Surface Elevation | Existing Conditions Water-Surface Elevation | Discharge cfs | Type 8 P. E. Future C. Water-Surface Elevation | Type 8 P. E. Existing C. Water-Surface Elevation |
|---|---|---|---|---|---|---|
| 200+50 | 14,600 | 91.9 | 91.5 | 14,600 | 92.0 | 91.5 |
| 200+00 | | 91.8 | 91.3 | | 91.5 | 91.7 |
| 199+50 | | 91.7 | 92.1 | | 91.4 | 92.7 |
| 199+00 | | 91.2 | 91.6 | | 91.5 | 91.9 |
| 198+50 | | 90.7 | 91.6 | | 90.9 | 91.9 |
| 198+00 | | 90.3 | 91.3 | | 90.0 | 91.5 |
| 197+50 | | 89.6 | 91.2 | | 90.2 | 91.7 |
| 197+00 | | 89.6 | 91.1 | | 89.8 | 91.3 |
| 196+50 | | 88.3 | 90.5 | | 88.2 | 90.9 |
| 196+00 | | 87.8 | 88.8 | | 87.5 | 88.6 |
| 195+50 | | 88.0 | 89.0 | | 88.2 | 88.8 |
| 195+00 | | 86.4 | 85.9 | | 85.6 | 86.0 |
| 194+50 | | 87.7 | 86.5 | | 86.7 | 86.4 |
| 194+00 | | 87.1 | 86.9 | | 87.0 | 87.4 |
| 193+50 | 6,020 F. C.; 6,530 E. C. | 86.6 | 86.5 | 6,150 F. C. and 6,420 E. C. | 86.3 | 86.6 |
| 193+00 | | 86.6 | 86.8 | | 86.2 | 86.6 |
| 192+50 | | 86.7 | 86.8 | | 86.2 | 86.8 |
| 192+00 | | 86.6 | 86.9 | | 86.5 | 86.8 |

## Table 54
## Guadalupe River and Bypass Culvert Flow Distribution for Various Modifications

| Discharge Conditions | Type Modification | Total Discharge cfs | Guadalupe River Discharge cfs | Bypass Culvert Discharge cfs | Obc/QT |
|---|---|---|---|---|---|
| Future | Type 16 Bypass Entrance<br>Type 19 Upstream Channel | 14,600 | 6,020 | 8,580 | 0.59 |
| Existing | Type 16 Bypass Entrance<br>Type 19 Upstream Channel | 14,600 | 6,530 | 8,070 | 0.55 |
| Future | Type 16 Bypass Entrance<br>Type 19 Upstream Channel<br>Type 8 Pier Extensions | 14,600 | 6,150 | 8,450 | 0.58 |
| Existing | Type 16 Bypass Entrance<br>Type 19 Upstream Channel<br>Type 8 Pier Extensions | 14,600 | 6,420 | 8,180 | 0.56 |
| Existing | Type 17 Bypass Entrance<br>Type 19 Upstream Channel<br>Type 8 Pier Extensions | 14,600 | 6,380 | 8,220 | 0.56 |
| Existing | Type 18 Bypass Entrance<br>Type 19 Upstream Channel | 14,600 | 6,520 | 8,080 | 0.55 |
| Existing | Type 19 Bypass Entrance<br>Type 19 Upstream Channel | 14,600 | 6,800 | 7,800 | 0.53 |
| Future | Type 20 Bypass Entrance<br>Type 19 Upstream Channel | 14,600 | 6,280 | 8,320 | 0.57 |
| Existing | Type 20 Bypass Entrance<br>Type 19 Upstream Channel | 14,600 | 6,680 | 7,920 | 0.54 |

Note: Manning's n for Guadalupe River = 0.05 with a discharge of 6,500 cfs in the river channel.
Qbc = Discharge in the bypass culvert.
Qt = Total discharge.

**Table 55**
**Guadalupe River Water-Surface Elevations, Type 19 Upstream Channel, Type 17 Bypass Entrance, Type 8 Pier Extensions, Ogee Weir El 79.77, Existing Conditions, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.0 at Sta 151+77**

| Sta | Discharge cfs | Elevation |
|---|---|---|
| 200+50 | 14,600 | 91.2 |
| 200+00 | | 91.7 |
| 199+50 | | 91.7 |
| 199+00 | | 92.1 |
| 198+50 | | 91.8 |
| 198+00 | | 91.5 |
| 197+50 | | 91.7 |
| 197+00 | | 91.2 |
| 196+50 | | 90.6 |
| 196+00 | | 88.3 |
| 195+50 | | 89.3 |
| 195+00 | | 85.8 |
| 194+50 | | 86.4 |
| 194+00 | | 87.5 |
| 193+50 | 6,380 | 86.6 |
| 193+00 | | 86.5 |
| 192+50 | | 86.6 |
| 192+00 | | 86.7 |

Table 56
Guadalupe River Water-Surface Elevations, Type 19 Upstream Channel, Type 20 Bypass Entrance, Bridge at GR5 Line, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.25 at Sta 151+27

| Sta | Discharge cfs | Existing Conditions Water-Surface Elevation | Discharge cfs | Future Water-Surface Elevation |
|---|---|---|---|---|
| 200+50 | 14,600 | 91.0 | 14,600 | 91.8 |
| 200+00 | | 91.0 | | 91.7 |
| 199+50 | | 91.5 | | 91.4 |
| 199+00 | | 91.6 | | 91.3 |
| 198+50 | | 91.6 | | 90.8 |
| 198+00 | | 91.3 | | 90.1 |
| 197+50 | | 91.2 | | 90.0 |
| 197+00 | | 91.1 | | 89.8 |
| 196+50 | | 90.2 | | 88.4 |
| 196+00 | | 88.5 | | 87.5 |
| 195+50 | | 89.1 | | 88.2 |
| 195+00 | | 85,5 | | 85.3 |
| 194+50 | | 86.6 | | 86.6 |
| 194+00 | | 86.7 | | 86.8 |
| 193+50 | 6,680 | 86.5 | 6,280 | 86.6 |
| 193+00 | | 86.8 | | 86.7 |
| 192+50 | | 87.1 | | 86.8 |
| 192+00 | | 87.0 | | 86.8 |
| Top of Weir | | 87.2 | | 87.1 |
| Top of Weir | | 84.8 | | 84.0 |
| Top of 1 ft Thick Divider Wall | | 87.8 | | 88.3 |

**Table 57**
**Bypass Culvert Water-Surface Elevations, Type 19 Upstream Channel, Type 20 Bypass Entrance, Bridge at GR5 Line, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Water-Surface Elevation of 77.25 at Sta 151+27**

| Sta | Existing Conditions Water-Surface Elevation | Future Conditions Water-Surface Elevation |
|---|---|---|
| 1 | 90.2 | 87.7 |
| 2 | 87.1 | 89.9 |
| 3 | 84.1 | 84.9 |
| 4 | 89.2 | 89.2 |
| 5 | 86.8 | 87.2 |
| 6 | 87.9 | 88.1 |
| 7 | 86.9 | 87.7 |
| 8 | 86.1 | 86.6 |
| 9 | 84.5 | 85.1 |
| 10 | 84.6 | 85.3 |

Table 58
Santa Clara Bridge Water-Surface Elevations, Discharge 14,600 cfs, Existing Conditions, Service Road in Place, With Debris on Piers

| Station | Left Wall | Station | Left Side Pier A | Station | Right Side Pier A | Station | Left Side Pier B | Station | Right Side Pier B | Station | Right Wall |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 156+15 | 77.3 | 156+15 | 77.3 | 156+15 | 77.3 | 156+15 | 77.1 | 156+15 | 77.4 | 156+15 | 77.3 |
| 156+08 | 77.3 | 156+05 | 78.9 | 156+05 | 79.1 | 156+05 | 78.9 | 156+05 | 79.0 | 156+02 | 76.5 |
| 156+00 | 77.1 | 155+94 | 75.0 | 155+93 | 74.9 | 155+91 | 74.0 | 155+93 | 75.5 | 155+82 | 76.9 |
| 155+88 | 77.2 | 155+87 | 77.5 | 155+84 | 77.4 | 155+83 | 77.6 | 155+82 | 77.9 | 155+65 | 77.0 |
| 155+81 | 77.3 | 155+64 | 77.2 | 155+64 | 77.0 | 155+64 | 77.0 | 155+65 | 76.5 | 155+50 | 77.2 |
| 155+50 | 77.6 | 155+50 | 77.1 | 155+50 | 77.1 | 155+50 | 77.2 | 155+47 | 78.1 | 155+27 | 77.1 |
| 155+10 | 77.2 | 155+10 | 76.9 | 155+10 | 77.0 | 155+10 | 76.8 | 155+40 | 76.6 | 155+10 | 77.3 |
| | | | | | | | | 155+23 | 78.3 | | |
| | | | | | | | | 155+10 | 76.3 | | |

Note: Pier A is pier on left side of channel looking downstream
Water-Surface Elevation at Sta 151+27 Guadalupe River 77.25

**Table 59**
**Water-Surface Elevations, Discharge 14,600 cfs, Service Road in Place, Under Santa Clara St. Bridge, Measurements With and Without Bridge Deck at Santa Clara St. Bridge**

| Station | With Deck | Station | Without Deck |
|---|---|---|---|
| **Tailwater El 77.0** | | | |
| 157+00 | 76.8 | 157+00 | 76.7 |
| 163+00 | 79.0 | 163+00 | 79.0 |
| **Tailwater El 77.25** | | | |
| 157+00 | 77.0 | 157+00 | 76.8 |
| 163+00 | 79.1 | 163+00 | 79.1 |

**Table 60**
**Guadalupe River Water-Surface Elevations on the Right and Left Overbanks, Type 19 Upstream Channel, Type 20 Bypass Entrance, Bridge at GR5 Line, Ogee Weir El 79.77, Discharge at Sta 203+00, 14,600 cfs, Left Overbank Discharge 3,500 cfs, Right Overbank Discharge 2,000 cfs**

| Left Overbank Location | Water-Surface Elevation | Right Overbank Location | Water-Surface Elevation |
|---|---|---|---|
| Upstream | 92.3 | Upstream | 92.2 |
| Center | 92.2 | Center | 92.2 |
| Downstream | 92.1 | Downstream | 92.1 |

**Table 61**
**Guadalupe River and Bypass Culvert Modifications**

| MODIFICATION | DESCRIPTION |
|---|---|
| Type 2 Bypass Entrance | The right wall at the entrance was extended upstream and out into the channel to intercept more river flow |
| Type 3 Bypass Entrance | The right wall at the entrance was extended an additional 50 ft upstream from the type 2 bypass entrance |
| Type 4 Bypass Entrance | Ogee weir shortened by 22 ft and ramp moved downstream |
| Type 5 Bypass Entrance | Right side of bypass entrance moved farther out into the Guadalupe River Channel which also increased the length of the ogee weir. The curvature of the weir was also reversed. |
| Type 6 Bypass Entrance | Right side of bypass entrance modified by extending diversion point 12.5 ft upstream from ogee weir |
| Type 7 Bypass Entrance | The right wall at the diversion was reshaped and the left Guadalupe River bankline just downstream from the diversion was modified |
| Type 8 Bypass Entrance | A wall extension was placed upstream from the existing divider wall |
| Type 9 Bypass Entrance | The wall extension in type 8 bypass entrance was sloped at upstream end |
| Type 10 Bypass Entrance | The existing upstream end of divider wall was increased in width from 4 to 5.5 ft |
| Type 11 Bypass Entrance | The upstream end of the existing divider wall was rotated approximately 7.5 ft to the right. |
| Type 12 Bypass Entrance | The upstream end of the existing divider wall was rotated approximately 6.3 ft to the right |
| Type 14 Bypass Entrance | The right side of the ogee weir was rotated upstream and the divider wall was increased in length. |
| Type 15 Bypass Entrance | A short deflector wall was placed on the outside of the right wall at the entrance |
| Type 16 Bypass Entrance | The upstream end of the 4-ft-thick divider wall was rotated toward the right side of the box culvert by 1.5 ft |
| Type 17 Bypass Entrance | A portion of the right wall was moved 2 ft out into the box culvert |
| Type 18 Bypass Entrance | The upstream end of the 4-ft-thick divider wall was moved back to its position in the type 15 bypass entrance and the right wall was placed back in its position with the type 16 bypass entrance |
| Type 19 Bypass Entrance | The left wall at the entrance was realigned and the right wall was moved back to its location with the type 17 bypass entrance |
| Type 20 Bypass Entrance | The right wall was placed back to its location with the type 16 bypass entrance and the left wall was left in its type 19 bypass entrance location |
| Type 2 Upstream Channel | Roughness elements were placed on the invert of the channel |
| Type 3 Upstream Channel | Sediment deposits were placed in the model on the right side of the channel at sta 196+50 |

(Sheet 1 of 3)

| Table 61 (Continued) | |
|---|---|
| **MODIFICATION** | **DESCRIPTION** |
| Type 4 Upstream Channel | A sediment buildup of 4.75 ft with a smooth surface was placed on the channel invert on the right side of the channel between stations 196+50 and 194+00 |
| Type 5 Upstream Channel | A sediment buildup of 9.5 ft with a smooth surface was placed on the channel invert on the right side of the channel between stations 196+50 and 194+00 |
| Type 6 Upstream Channel | A sediment buildup of 9.5 ft with a rough surface was placed on the channel invert on the right side of the channel between stations 196+50 and 194+00 |
| Type 7 Upstream Channel | The right bankline between sta's 196+50 and 194+00 was reshaped |
| Type 8 Upstream Channel | The right bankline between sta's 196+50 and 194+00 was reshaped |
| Type 9 Upstream Channel | The left wall was moved out into the Guadalupe River Channel between sta 200+00 and weir to provide seismic stability for piers on left overbank |
| Type 10 Upstream Channel | The right side of the channel was modified between sta's 198+50 and 196+00 by moving the bankline out into the Guadalupe River |
| Type 11 Upstream Channel | The right side of the channel was modified between sta's 196+00 and 193+50 by bulging out the bankline into the Guadalupe River |
| Type 12 Upstream Channel | A portion of the bulge from the Type 11 U/S Channel was removed |
| Type 13 Upstream Channel | The left wall was modified by beginning the wall around sta 198+60 |
| Type 14 Upstream Channel | The left wall was modified between sta's 199+50 and 197+00 and the right side of the channel was modified between sta's 200+50 and 197+00 |
| Type 15 Upstream Channel | The left wall was modified between sta's 199+50 and 195+50 |
| Type 16 Upstream Channel | Temporary modification upstream from weir |
| Type 17 Upstream Channel | Type 16 upstream channel constructed from sheet metal |
| Type 18 Upstream Channel | The left wall was modified between sta's 199+50 and weir the right side of channel was modified between sta's 200+50 and 193+00 |
| Type 19 Upstream Channel | The right side of the channel was modified between stations 195+50 and 193+00 |
| Type 1 Pier Extensions | Pier extensions place on all piers between sta's 198+00 and 195+00 |
| Type 2 Pier Extensions | No pier extensions placed on piers between sta's 198+00 and 195+00 |
| Type 3 Pier Extensions | Pier extensions on piers between sta's 198+00 and 195+00 only |
| Type 4 Pier Extensions | Pier extensions placed on all piers between sta's 200+00 and 194+00 except the three between sta 197+00 and sta 195+00 |
| Type 5 Pier Extensions | Sloped pier extensions placed on all piers between sta's 200+00 and 194+00 and a new pier added in the future channel |
| Type 6 Pier Extensions | The three piers located between sta's 197+00 and 195+00 in the type 5 pier extensions were removed. |
| | (Sheet 2 of 3) |

| Table 61 (Concluded) | |
|---|---|
| **MODIFICATION** | **DESCRIPTION** |
| Type 7 Pier Extensions | The temporary pier extensions used in the type 6 pier extension design were replaced with designs developed from EM 1110-2-1601. |
| Type 8 Pier Extensions | The location of the piers between stations 201+00 and 194+00 was changed slightly. |
| Type 2 Weir | The crest el of the original weir was lowered to el 79.02 |
| Type 3 Weir | The ogee was replaced with a thin sharp-crested weir 88.66 ft long at el 79.02 |
| Type 4 Weir | A semi-circular shaped arcs at el 79.02 |
| Type 5 Weir | Four semi-circular shaped arcs at el 79.02 |
| Downstream Wall Modification | The left wall was moved out into the channel between stations 161+00 and 156+00 |
| Fountain Design | The supporting walls for a water fountain proposed for placement in the channel were placed on the outside of the right culvert wall at the confluence |

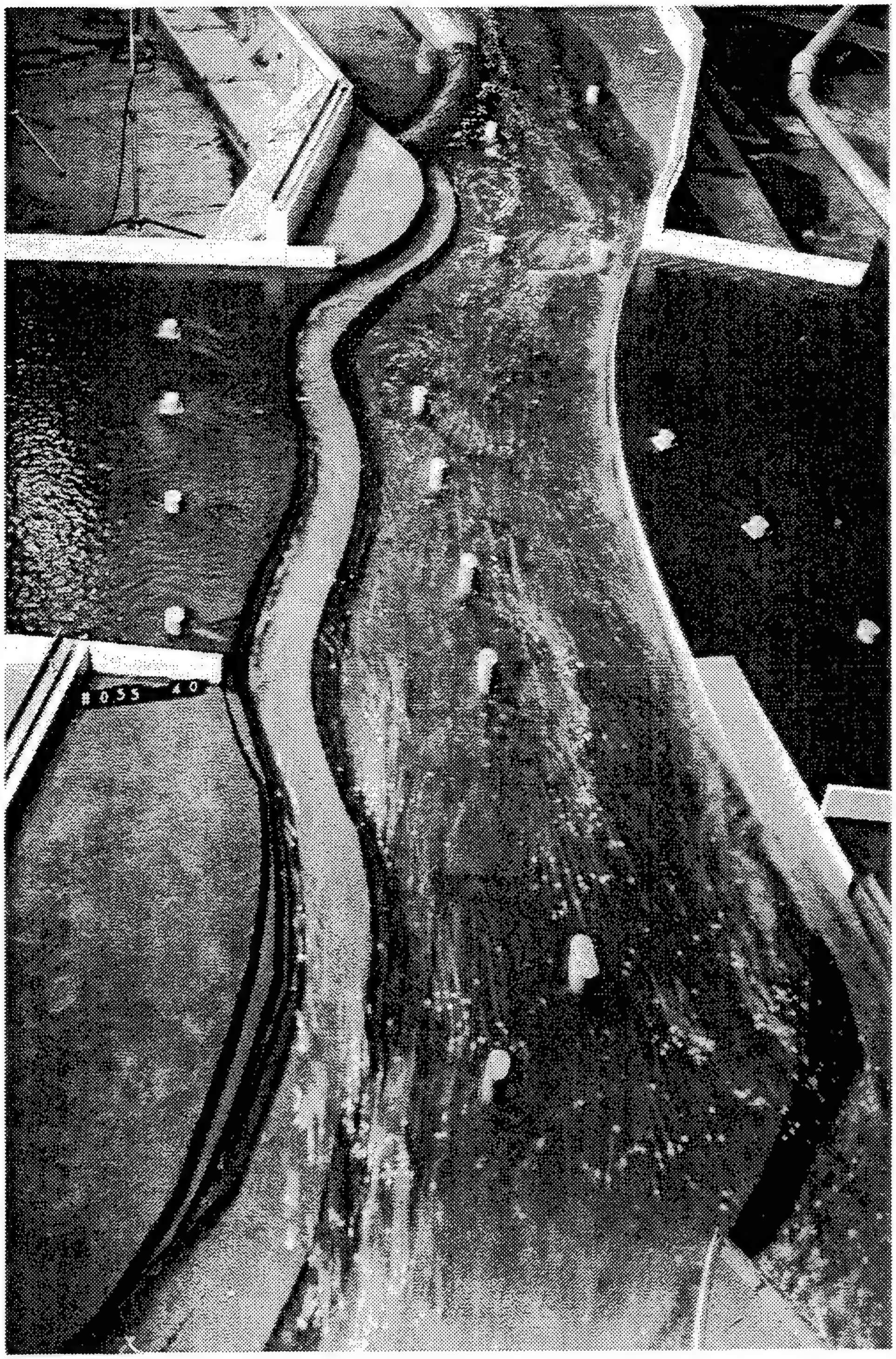


Photo 1. Looking upstream from sta 194+00 at flow conditions in the upstream channel with the type 1 design, existing conditions, and a discharge of 14,600 cfs and confetti placed on the surface to highlight surface patterns

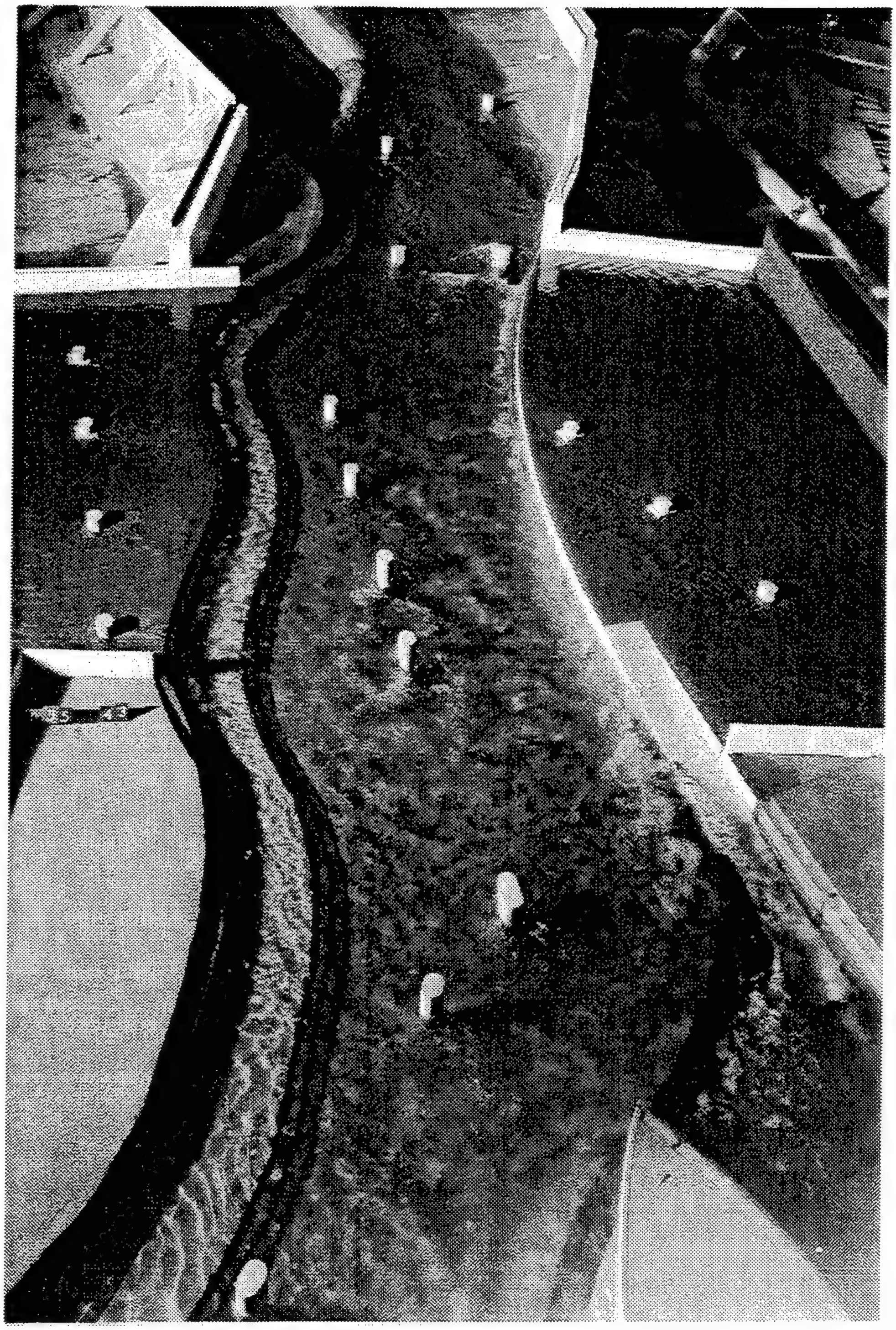


Photo 2. Looking upstream from sta 194+00 at flow conditions in the upstream channel with the type 1 design, existing conditions, and a discharge of 14,600 cfs

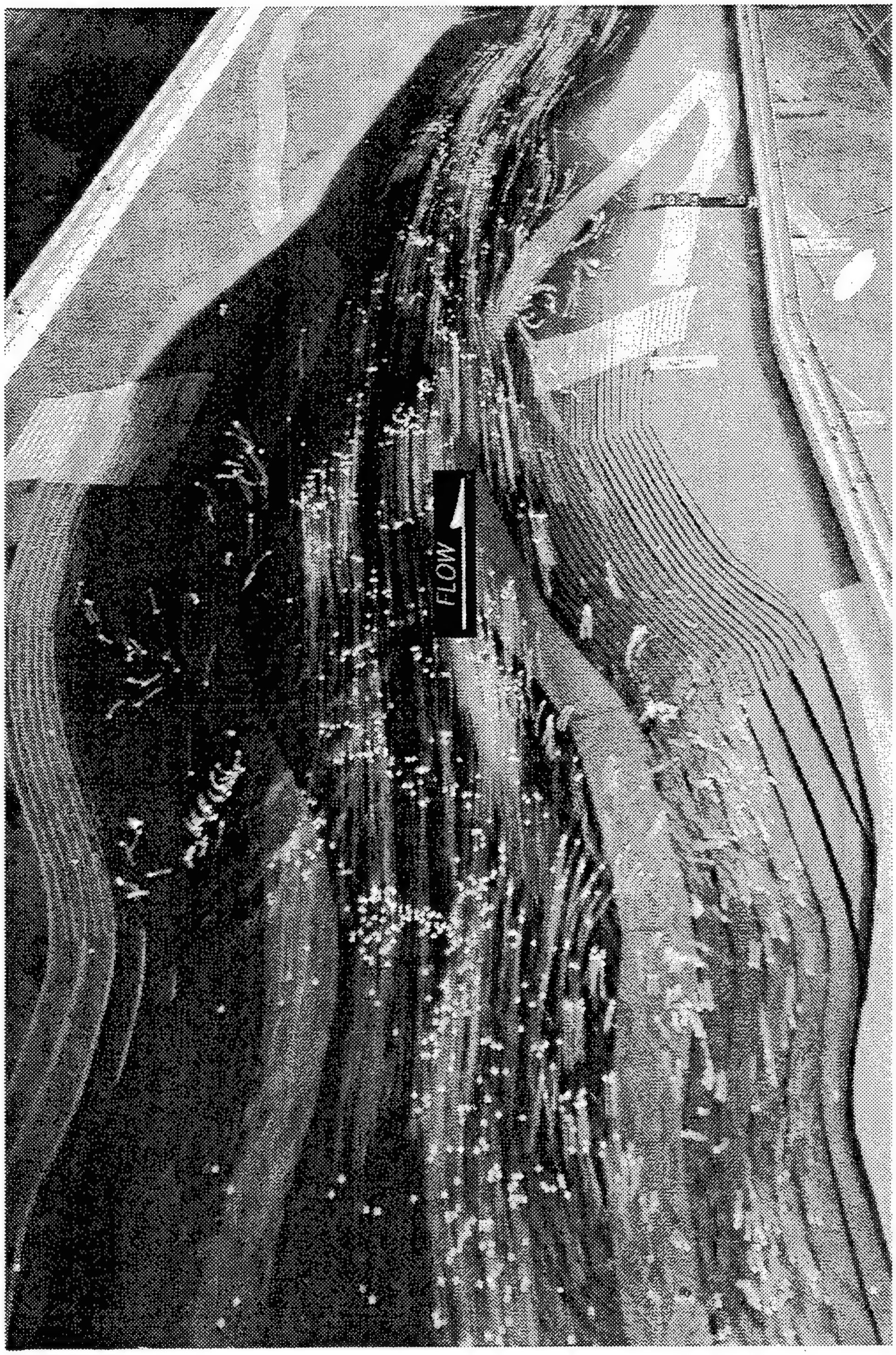



Photo 3. Looking downstream from sta 193+00 at flow conditions in the Guadalupe River with the type 1 design, existing conditions, and a discharge of 14,600 cfs and confetti placed on the surface to highlight surface patterns

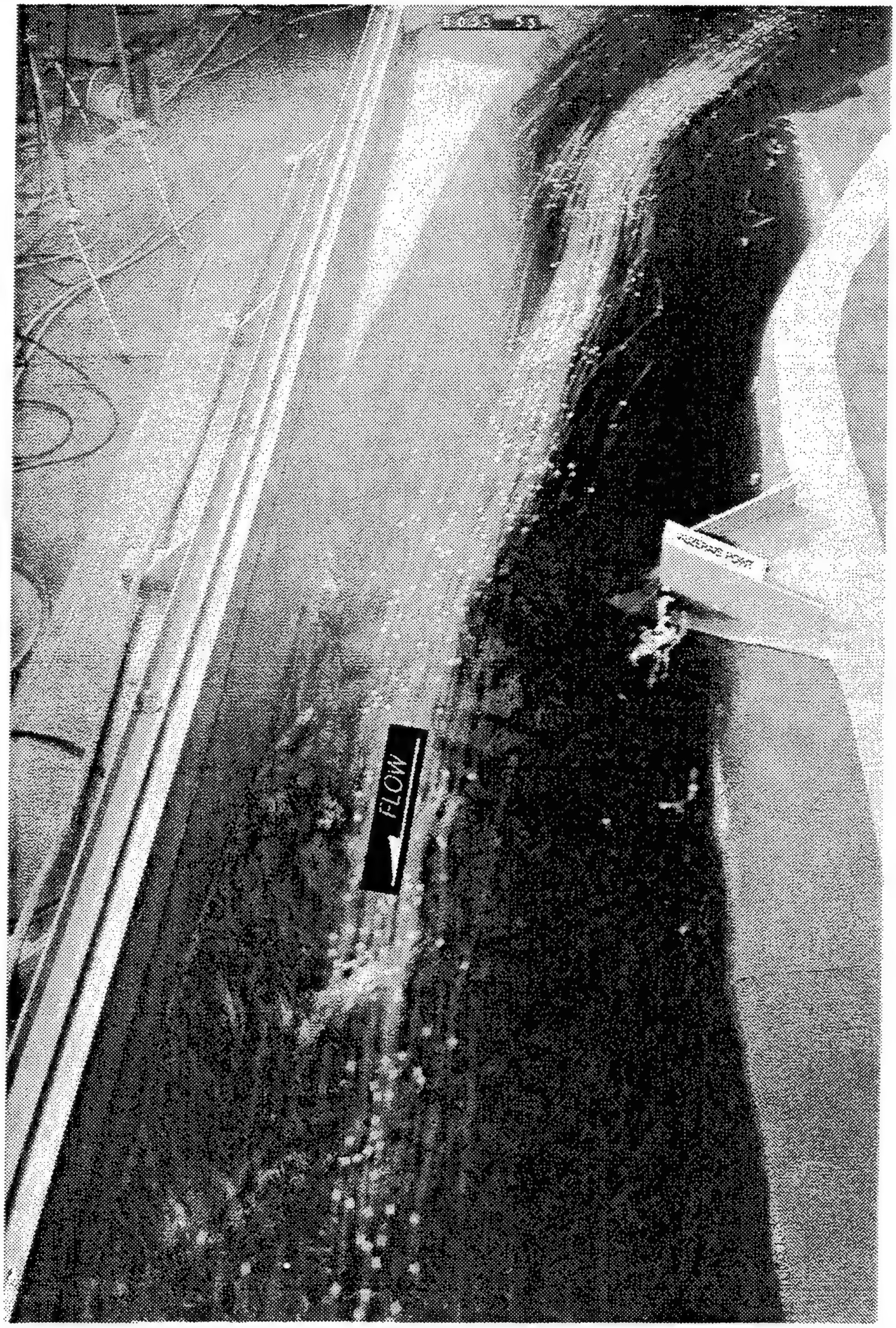



Photo 4. Looking upstream from sta 181+00 at flow conditions in the Guadalupe River with the type 1 design, existing conditions, and a discharge of 14,600 cfs and confetti placed on the surface to highlight surface patterns

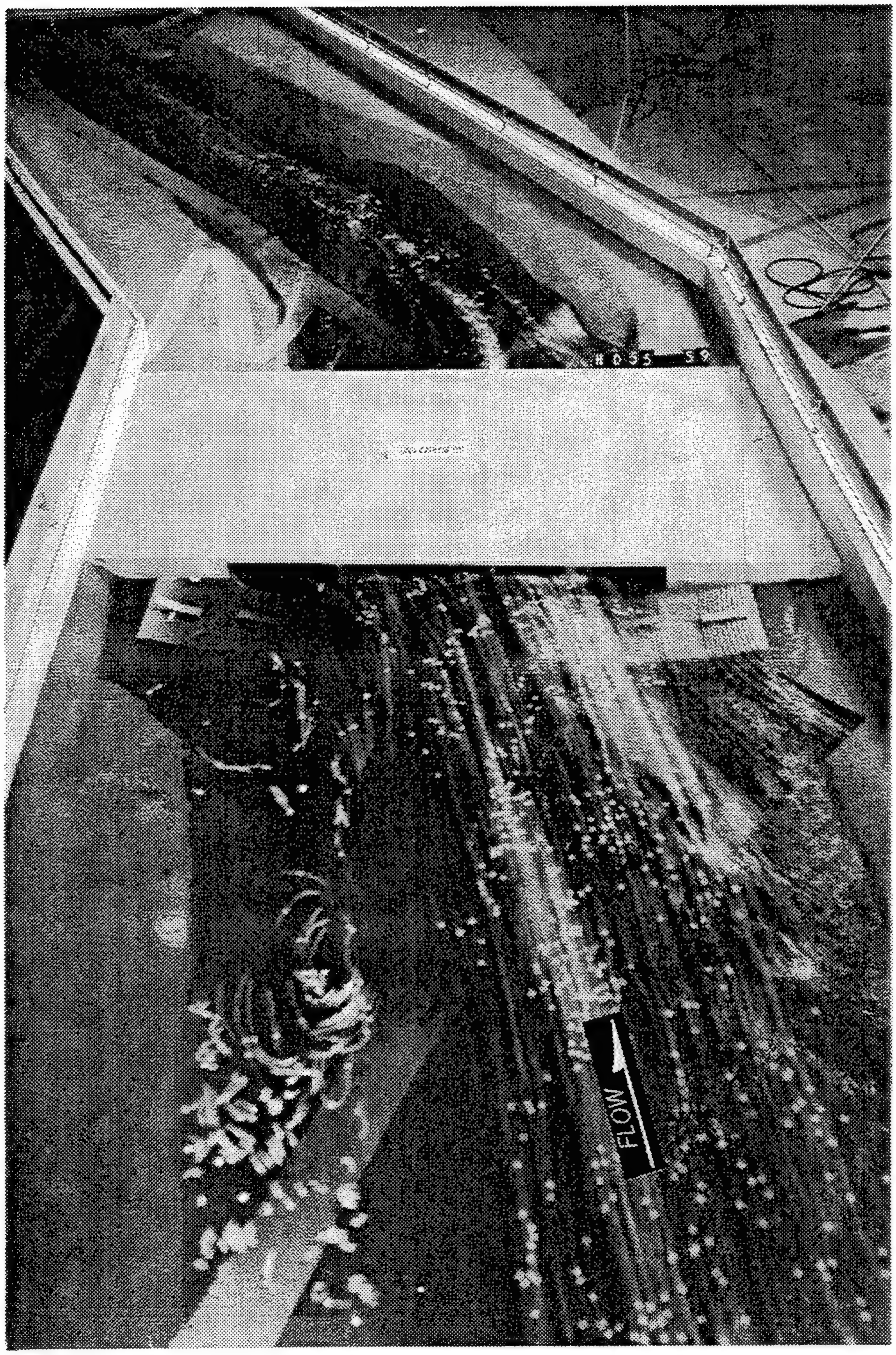



Photo 5. Looking downstream from sta 179+00 at flow conditions in the Guadalupe River with the type 1 design, existing conditions, and a discharge of 14,600 cfs and confetti placed on the surface to highlight surface patterns

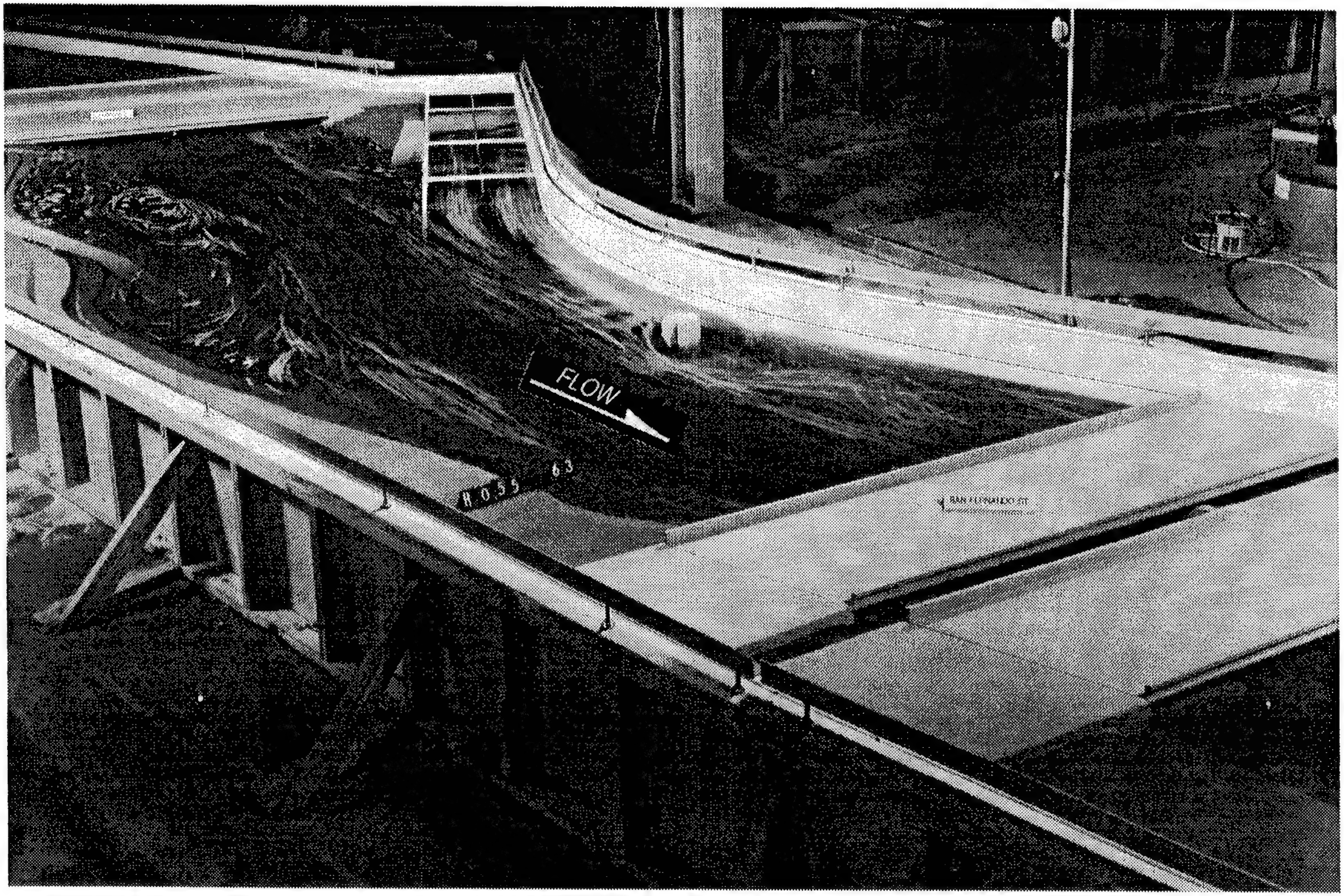



Photo 6. Looking upstream from sta 163+00 at flow conditions at the confluence of the Guadalupe River and bypass culvert with the type 1 design, existing conditions, and a discharge of 14,600 cfs and confetti placed on the surface to highlight surface patterns

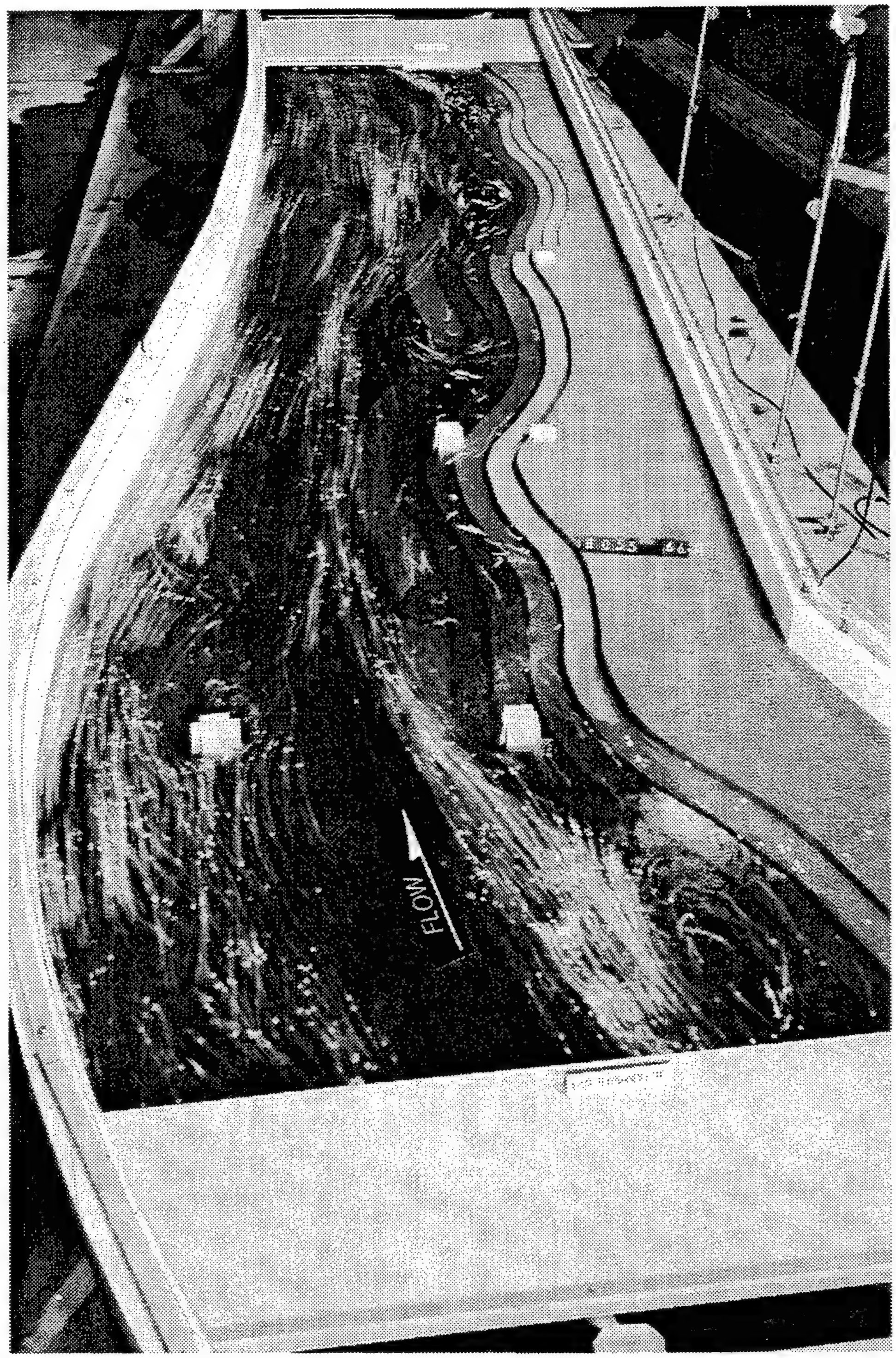



Photo 7. Looking downstream from sta 163+00 at flow conditions in the Guadalupe River with the type 1 design, existing conditions, and a discharge of 14,600 cfs and confetti placed on the surface to highlight surface patterns

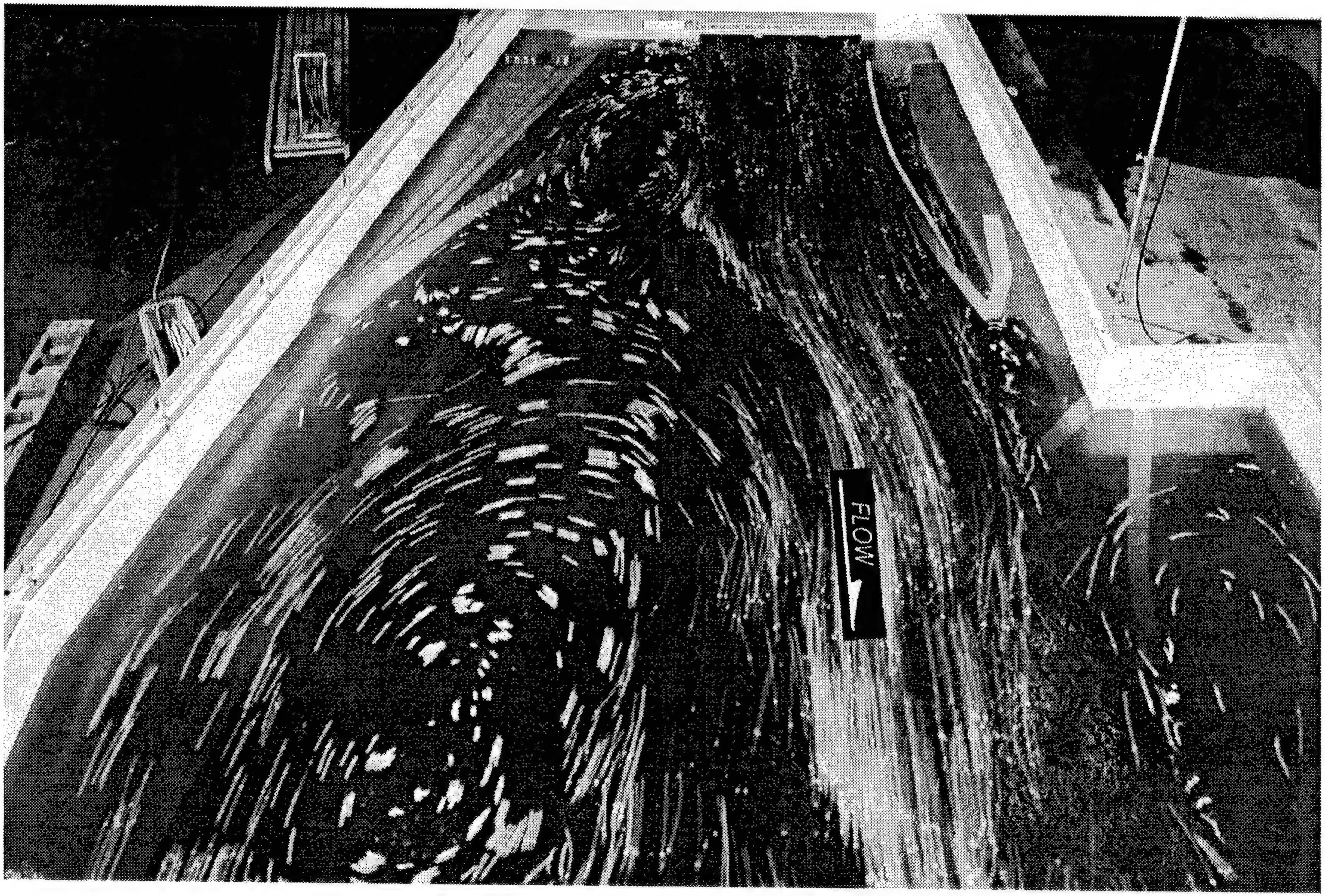



Photo 8. Looking upstream from sta 152+00 at flow conditions in the Guadalupe River downstream from the Santa Clara St. Bridge with the type 1 design, existing conditions, and a discharge of 14,600 cfs and confetti placed on the surface to highlight surface patterns

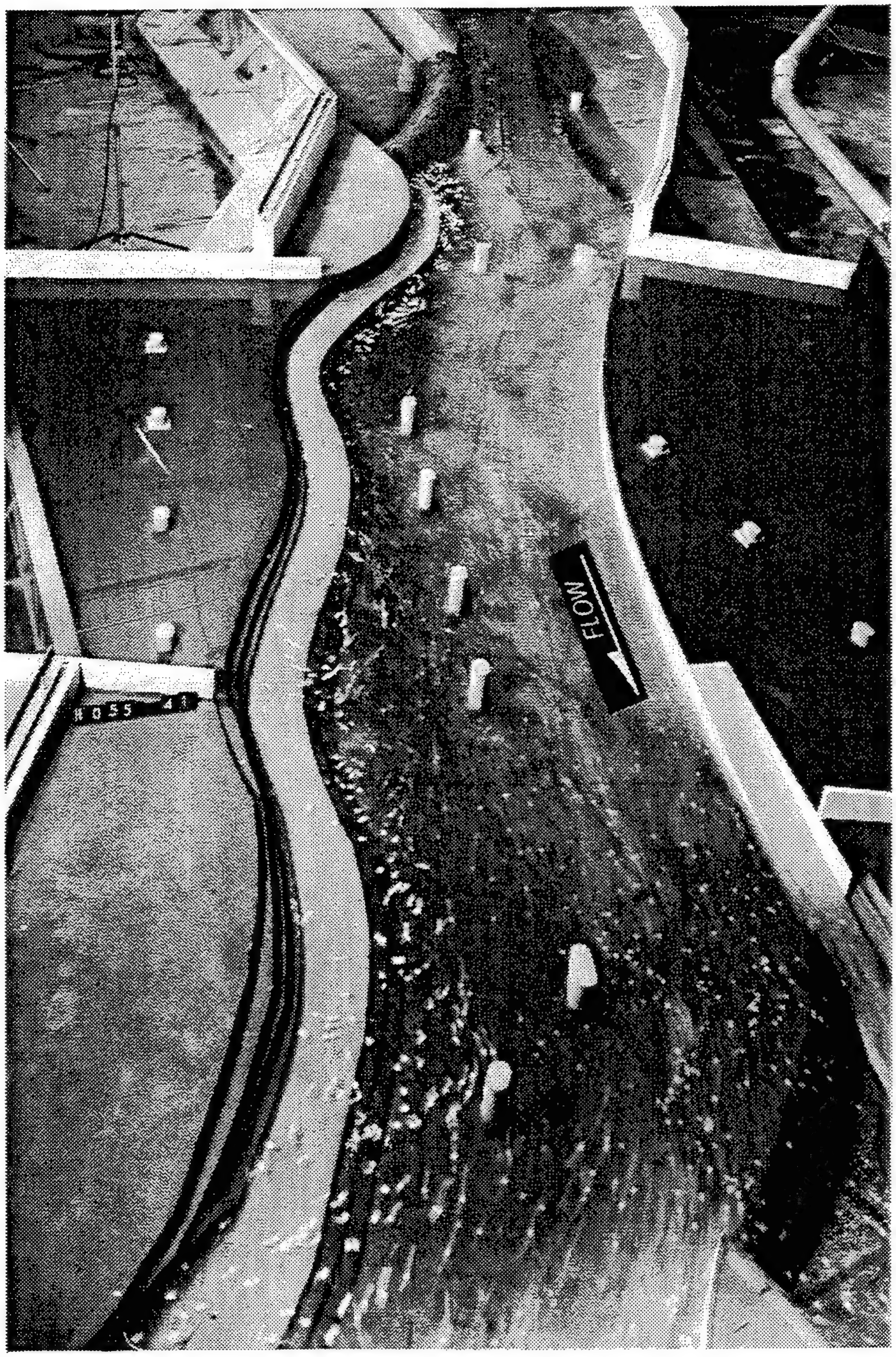



Photo 9. Looking upstream from sta 194+00 at flow conditions in the upstream channel with the type 1 design, existing conditions, and a discharge of 9,100 cfs and confetti placed on the surface to highlight surface patterns

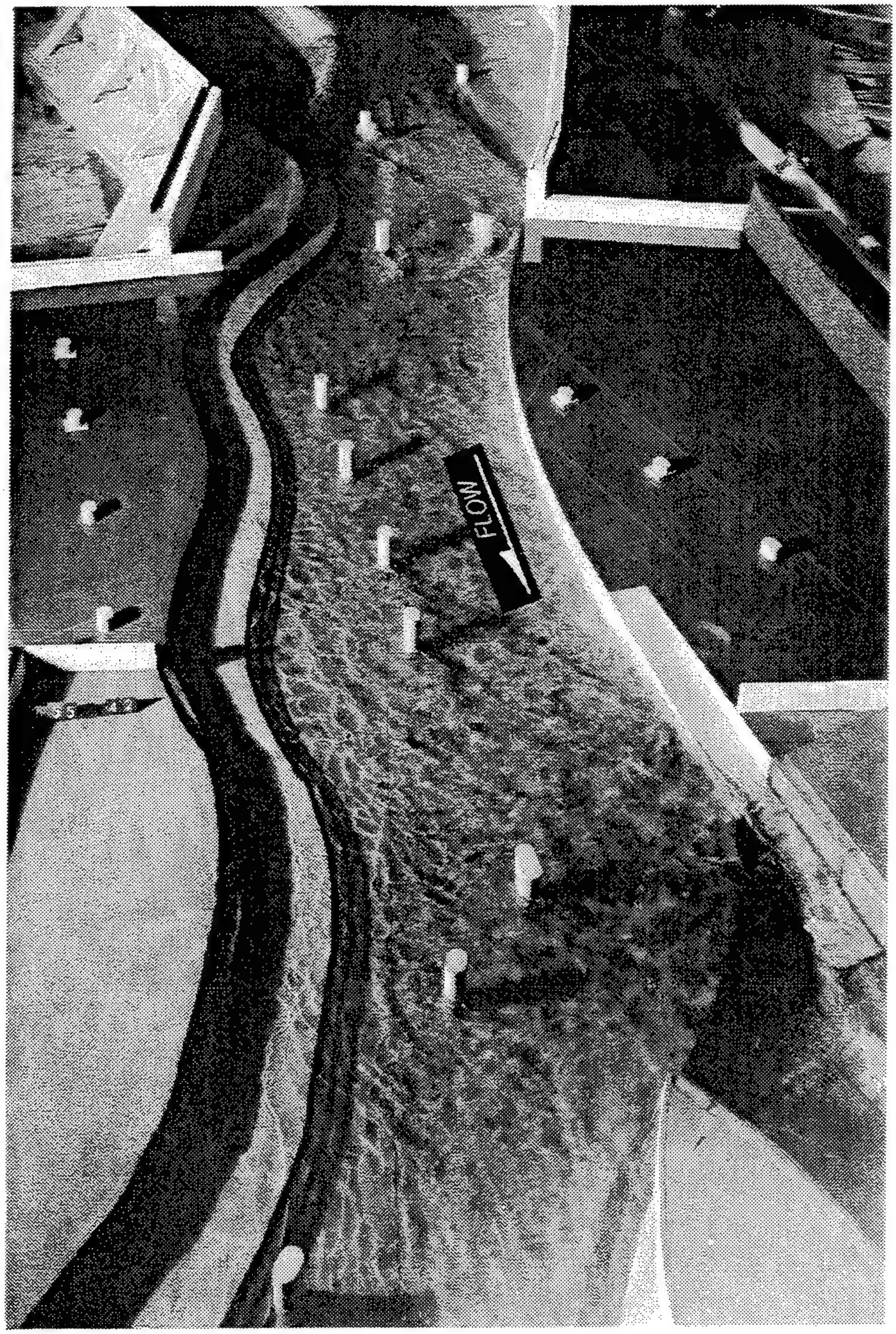


Photo 10. Looking upstream from sta 194+00 at flow conditions in the upstream channel with the type 1 design, existing conditions, and a discharge of 9,100 cfs

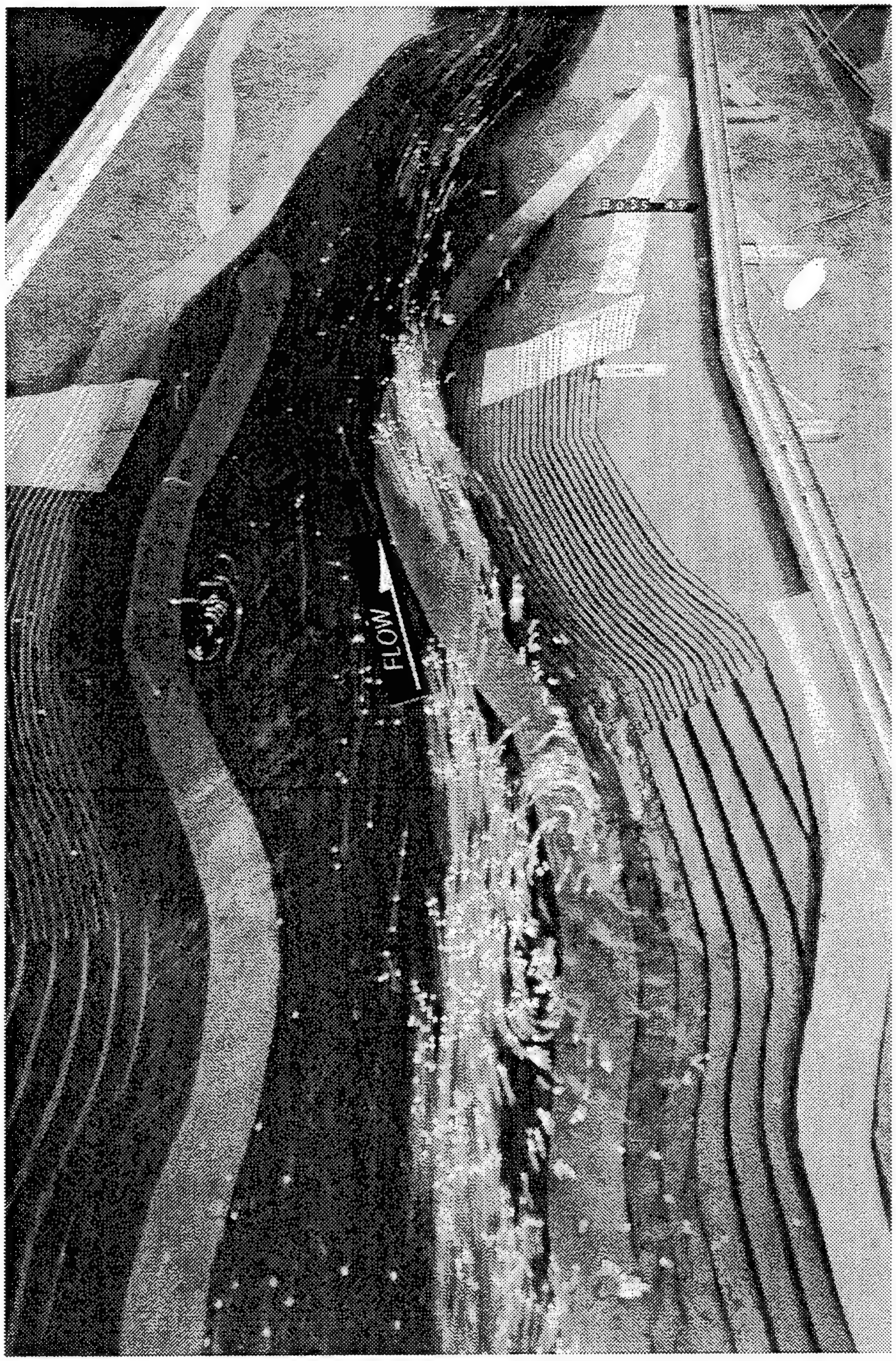



Photo 11. Looking downstream from sta 193+00 at flow conditions in the Guadalupe River with the type 1 design, existing conditions, and a discharge of 9,100 cfs and confetti placed on the surface to highlight surface patterns

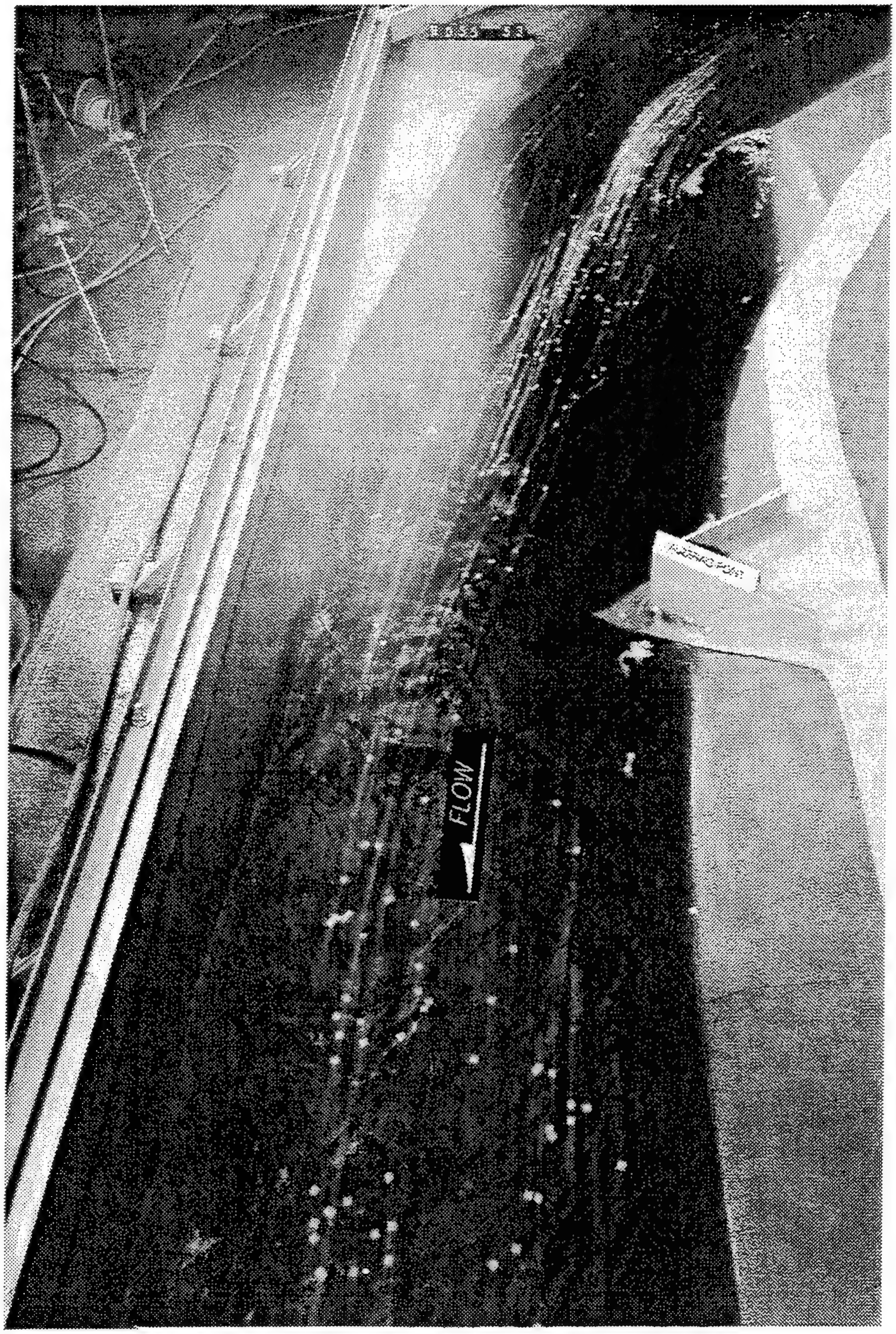



Photo 12. Looking upstream from sta 181+00 at flow conditions in the Guadalupe River with the type 1 design, existing conditions, and a discharge of 9,100 cfs and confetti placed on the surface to highlight surface patterns

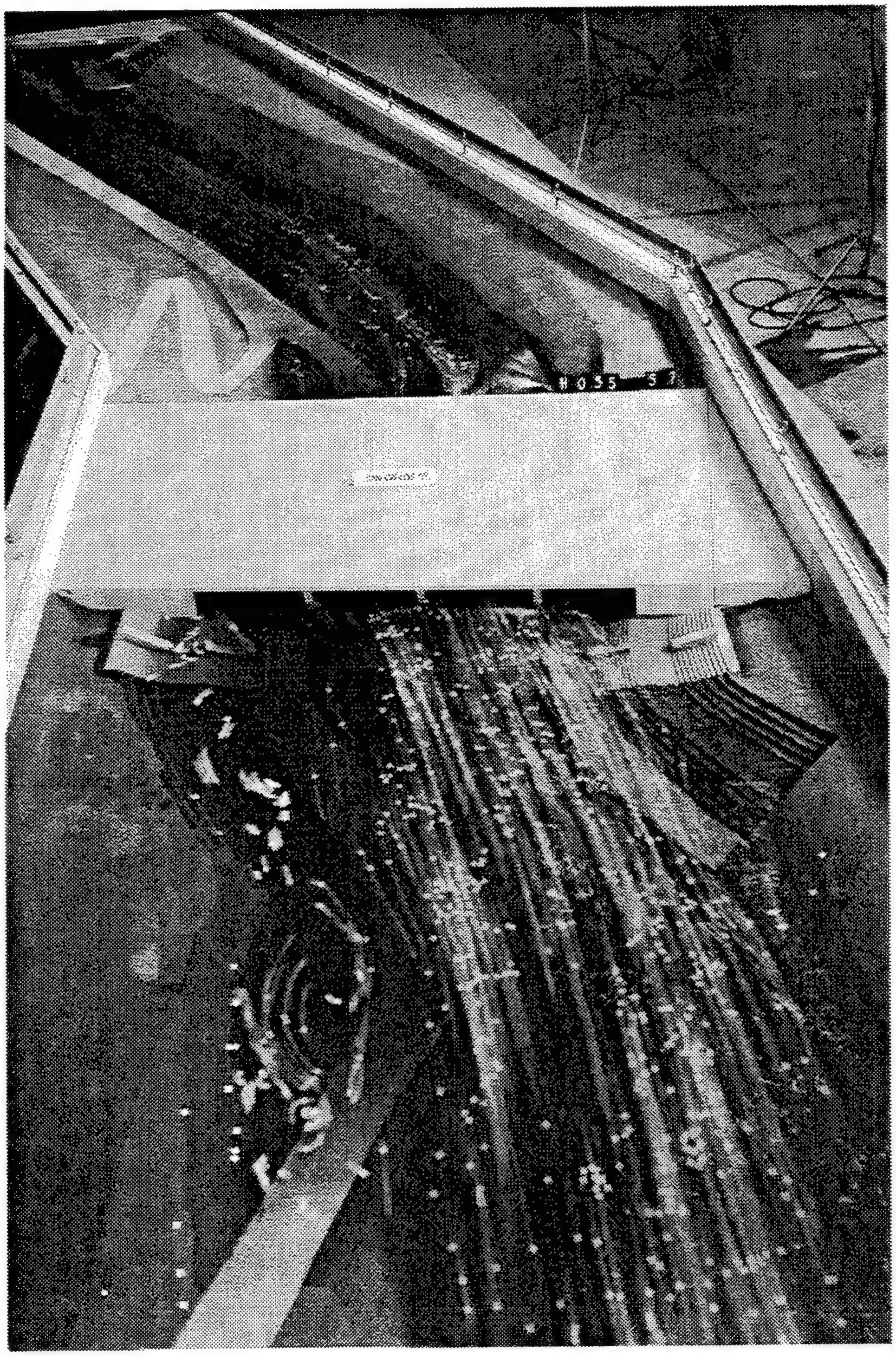


Photo 13. Looking downstream from sta 179+00 at flow conditions in the Guadalupe River with the type 1 design, existing conditions, and a discharge of 9,100 cfs and confetti placed on the surface to highlight surface patterns

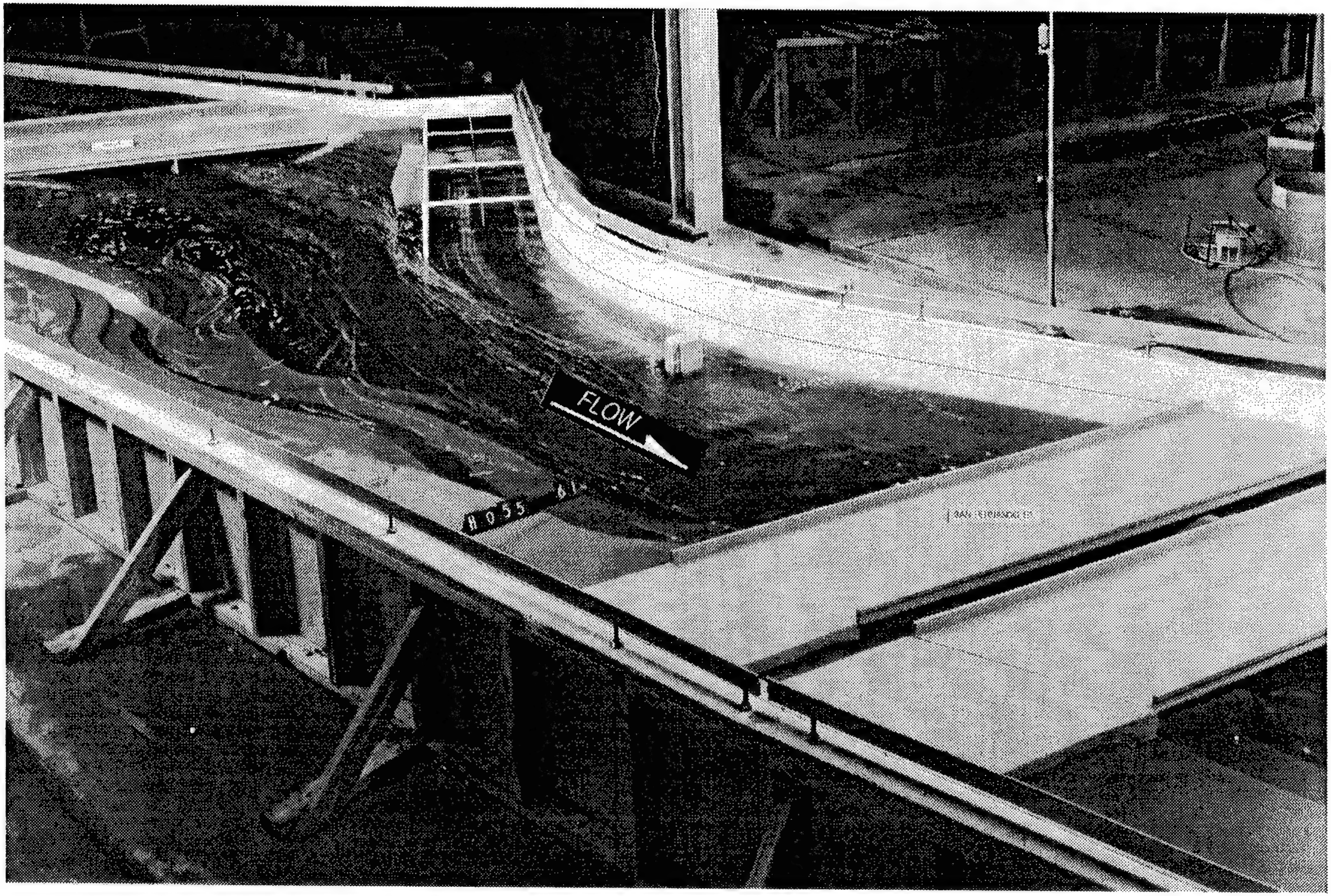



Photo 14. Looking upstream from sta 163+00 at flow conditions at the confluence of the Guadalupe River and the bypass culvert with the type 1 design, existing conditions, and a discharge of 9,100 cfs and confetti placed on the surface to highlight surface patterns


Photo 15. Looking downstream from sta 163+00 at flow conditions in the Guadalupe River with the type 1 design, existing conditions, and a discharge of 9,100 cfs and confetti placed on the surface to highlight surface patterns

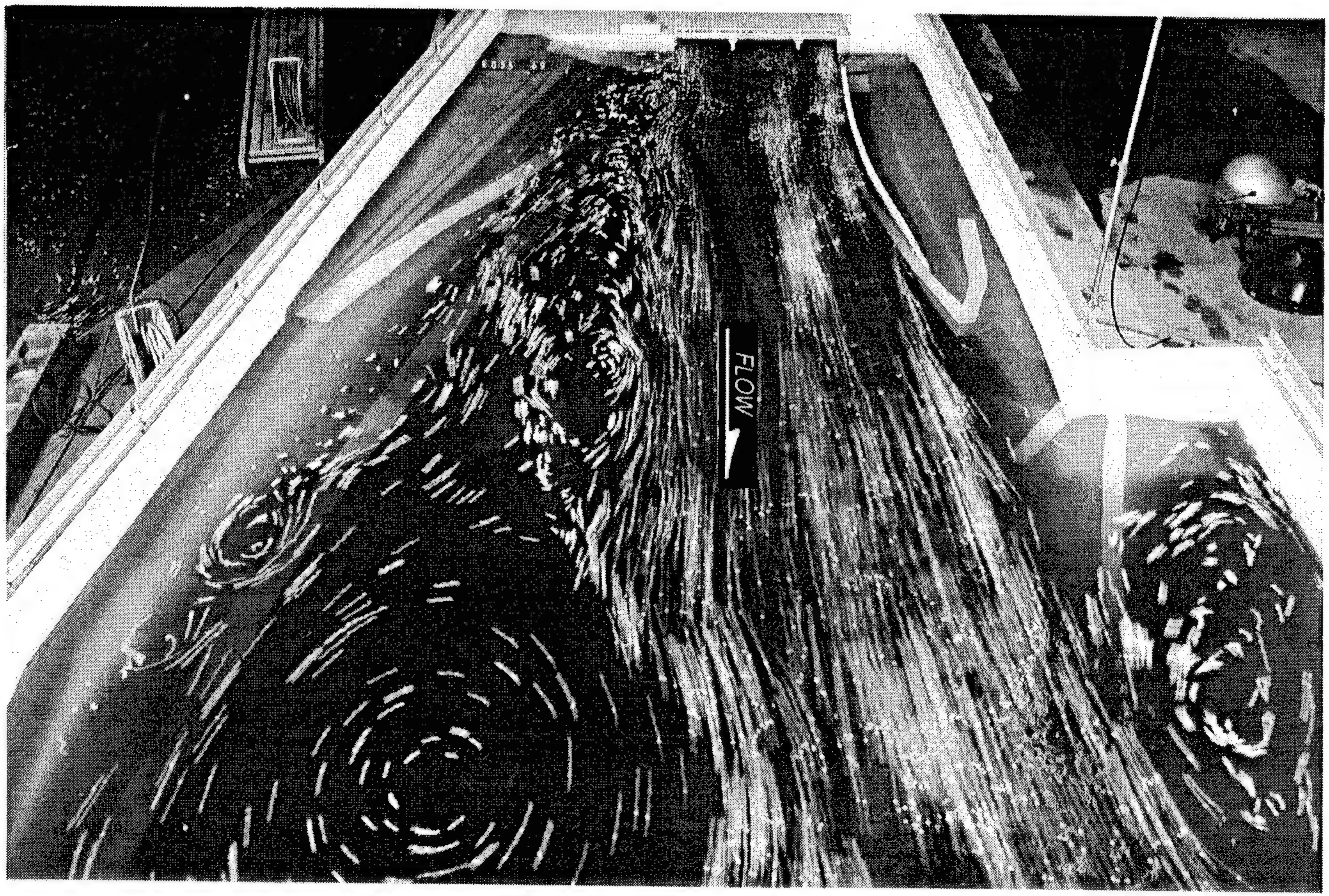



Photo 16. Looking upstream from sta 152+00 at flow conditions in the Guadalupe River downstream from the Santa Clara St. Bridge with the type 1 design, existing conditions, and a discharge of 9,100 cfs and confetti placed on the surface to highlight surface patterns

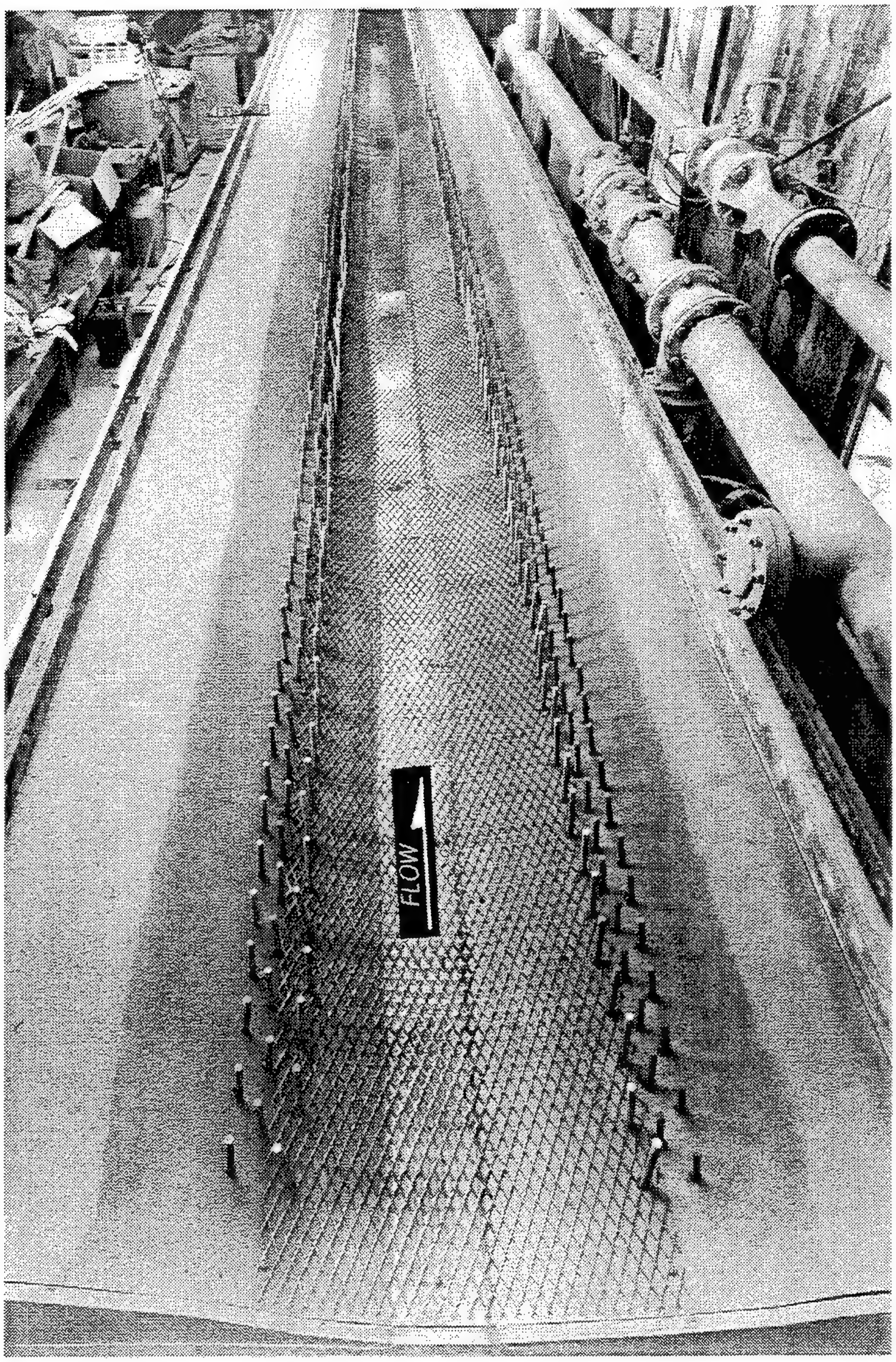



Photo 17. Dry bed view looking downstream of flume used to perform model roughness experiments. Model elements represent Manning's n of 0.05 at bankfill flow of 6,500 cfs

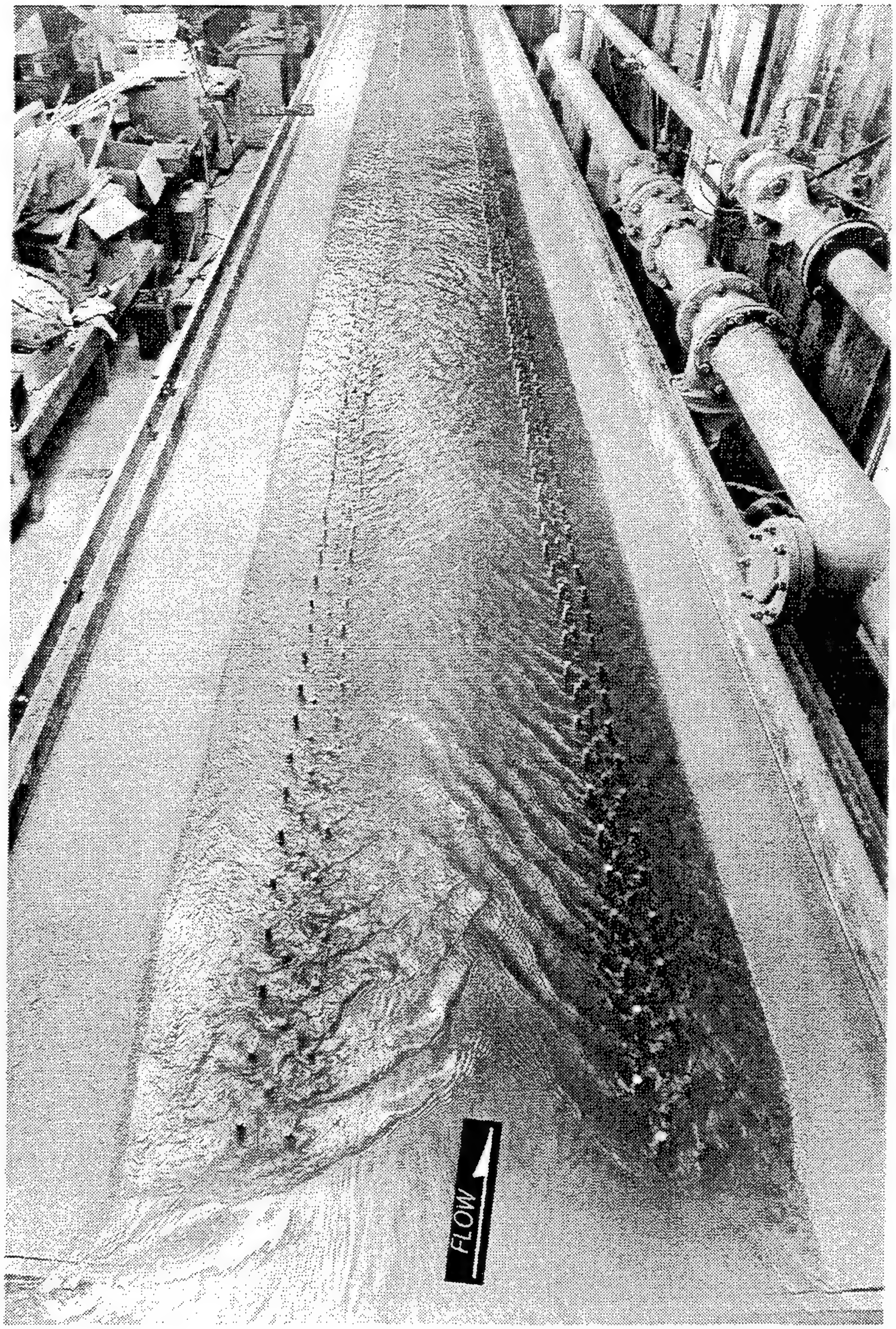



Photo 18. Looking downstream at flow conditions in flume with a discharge of 6,500 cfs and model elements that represent Manning's n of 0.05

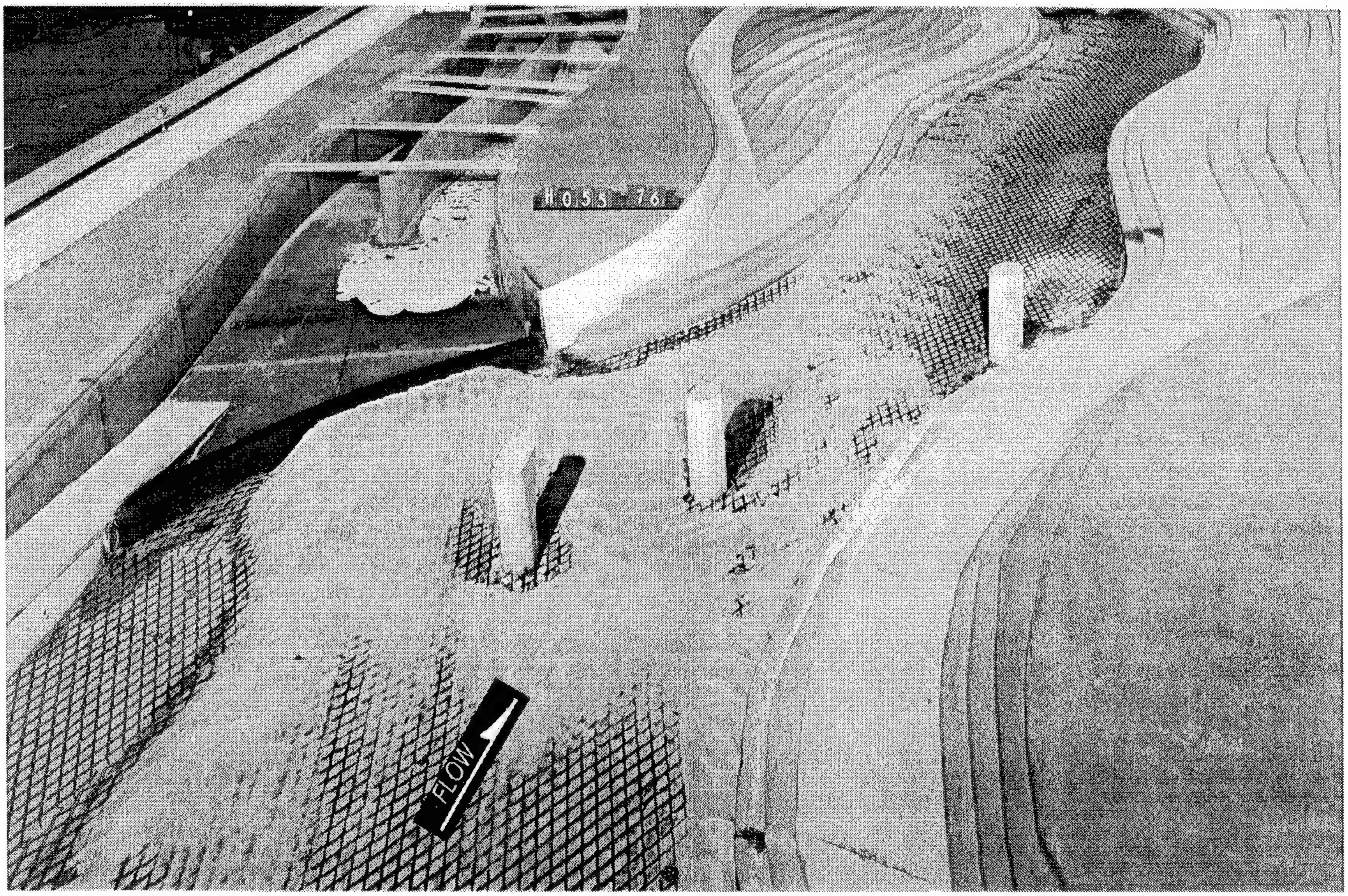



Photo 19. View looking downstream at sediment deposits near the weir after first sediment experiment

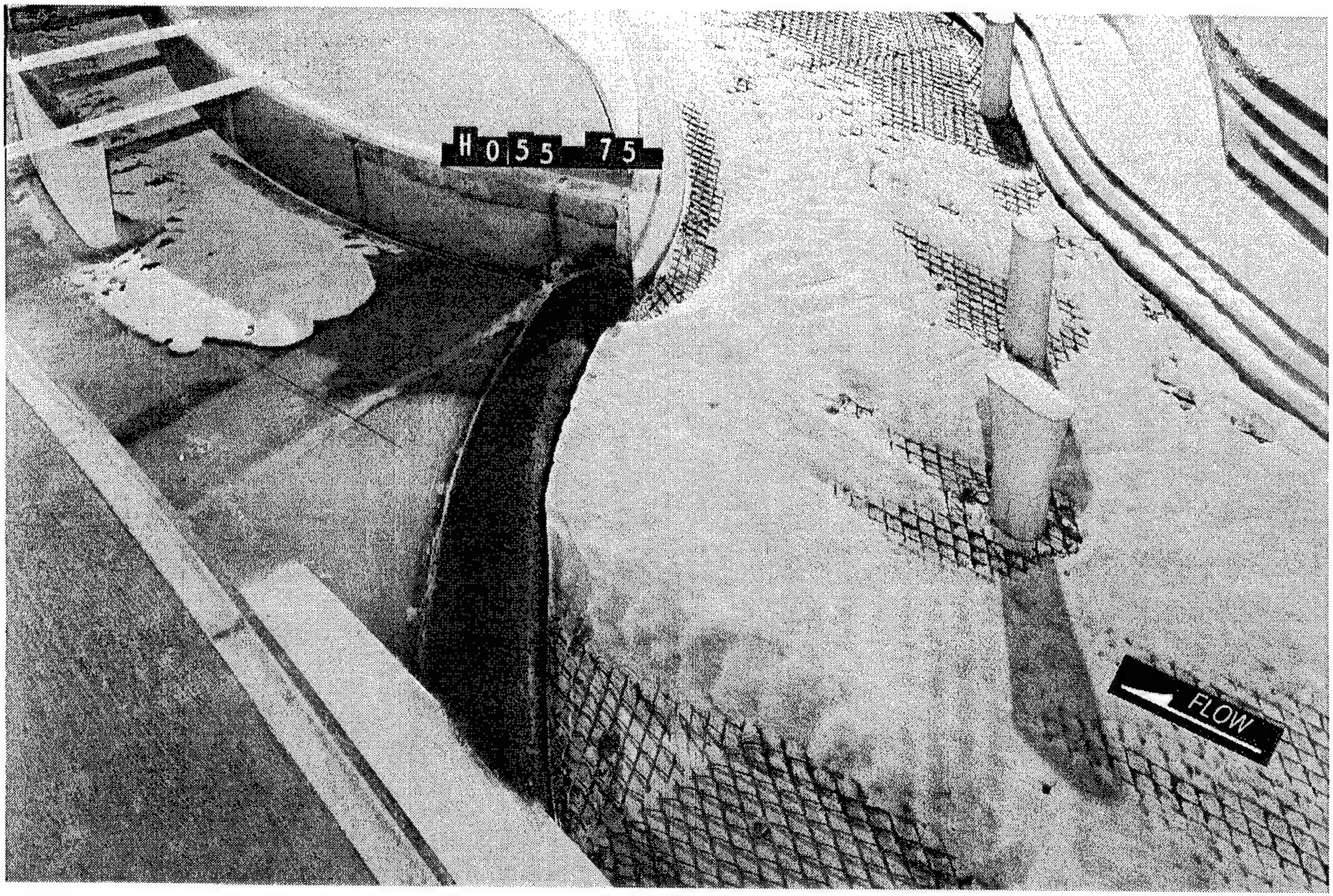



Photo 20. View of sediment deposits at weir after first sediment experiment

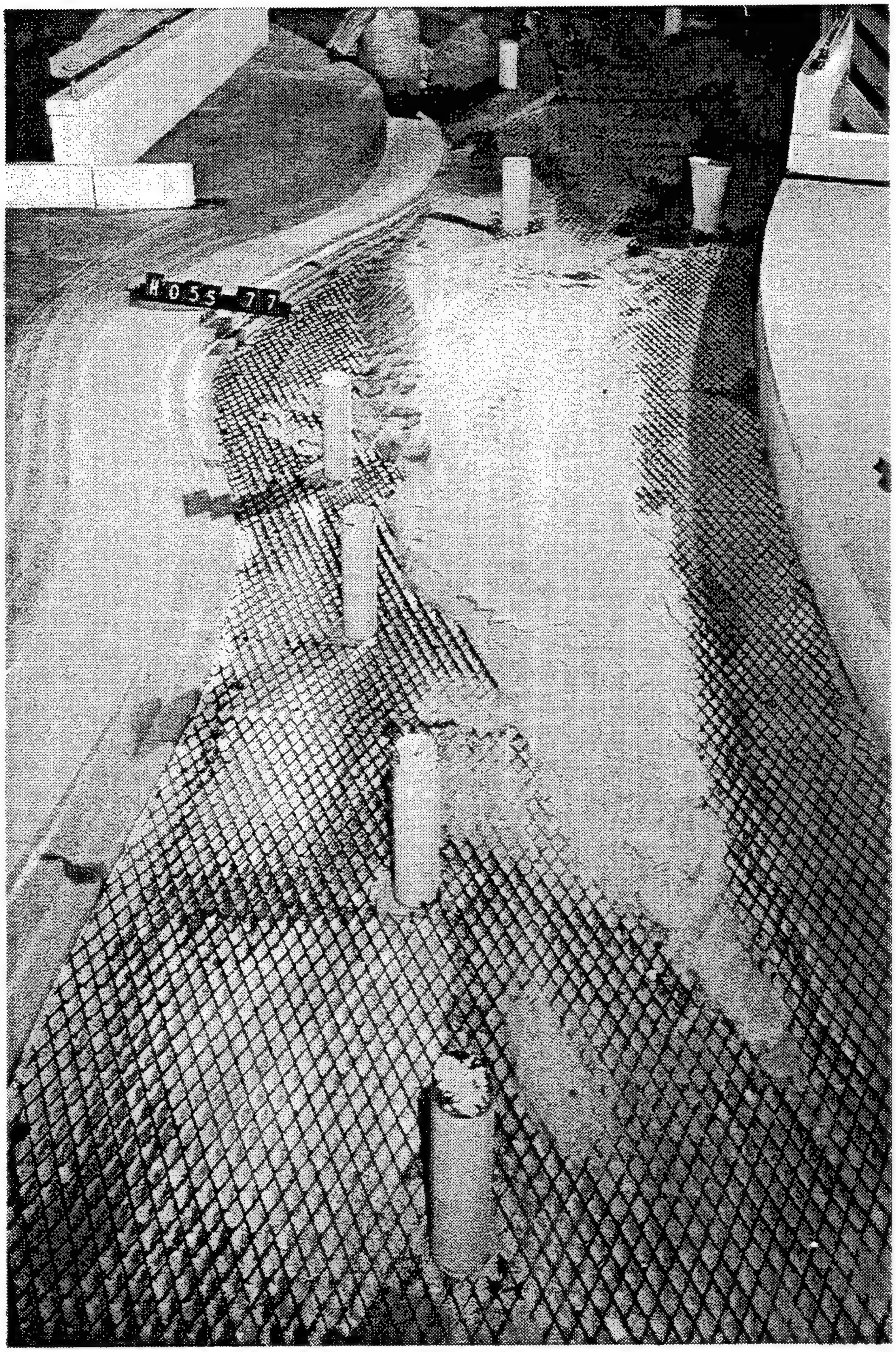



Photo 21. View looking upstream from weir of sediment deposits in the upstream channel after first sediment experiment

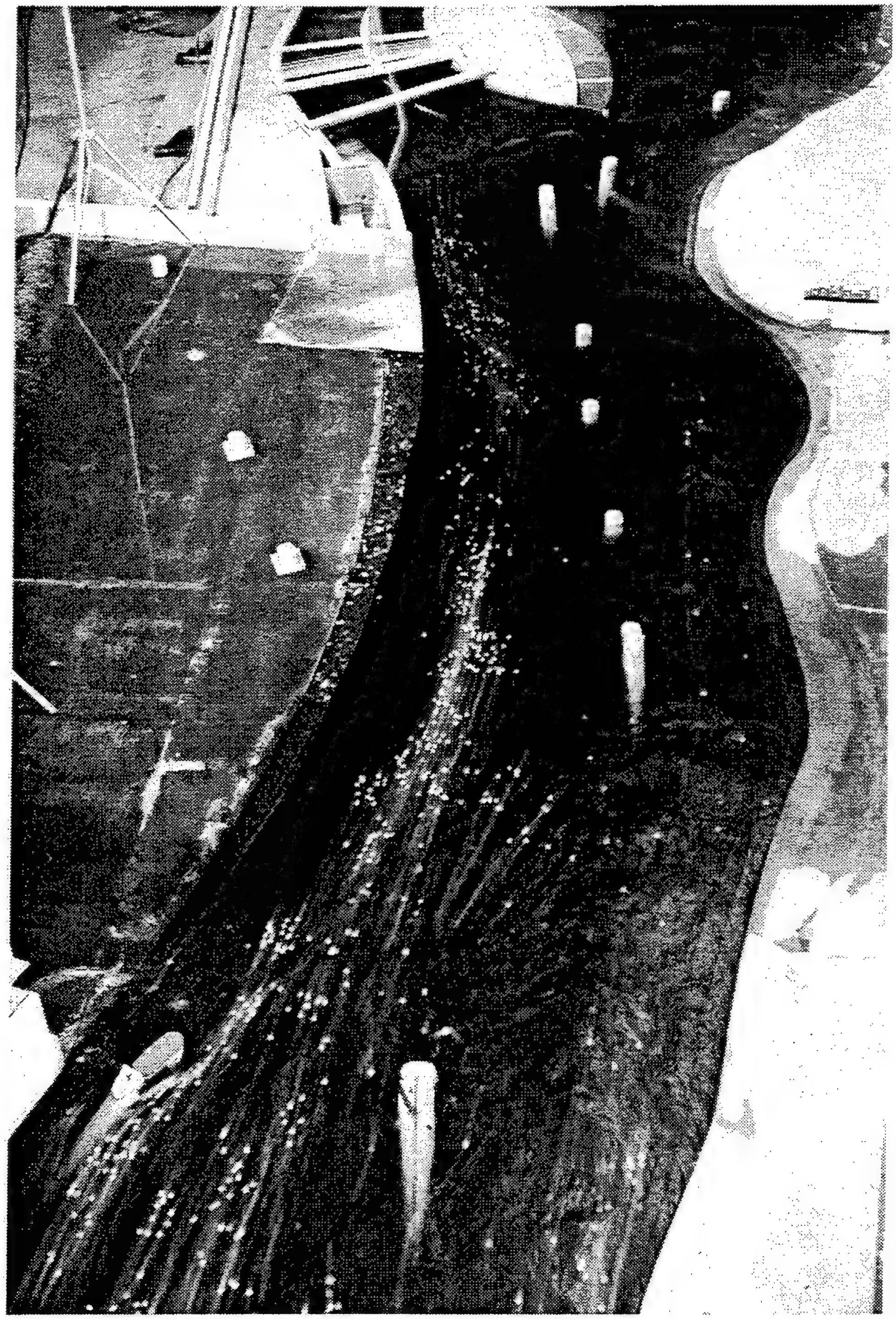


Photo 22. Looking downstream at flow conditions in the upstream channel between sta 199+00 and the entrance to the bypass culvert with the type 19 upstream channel, type 16 bypass entrance, and type 8 pier extensions with future conditions and a discharge of 14,600 cfs

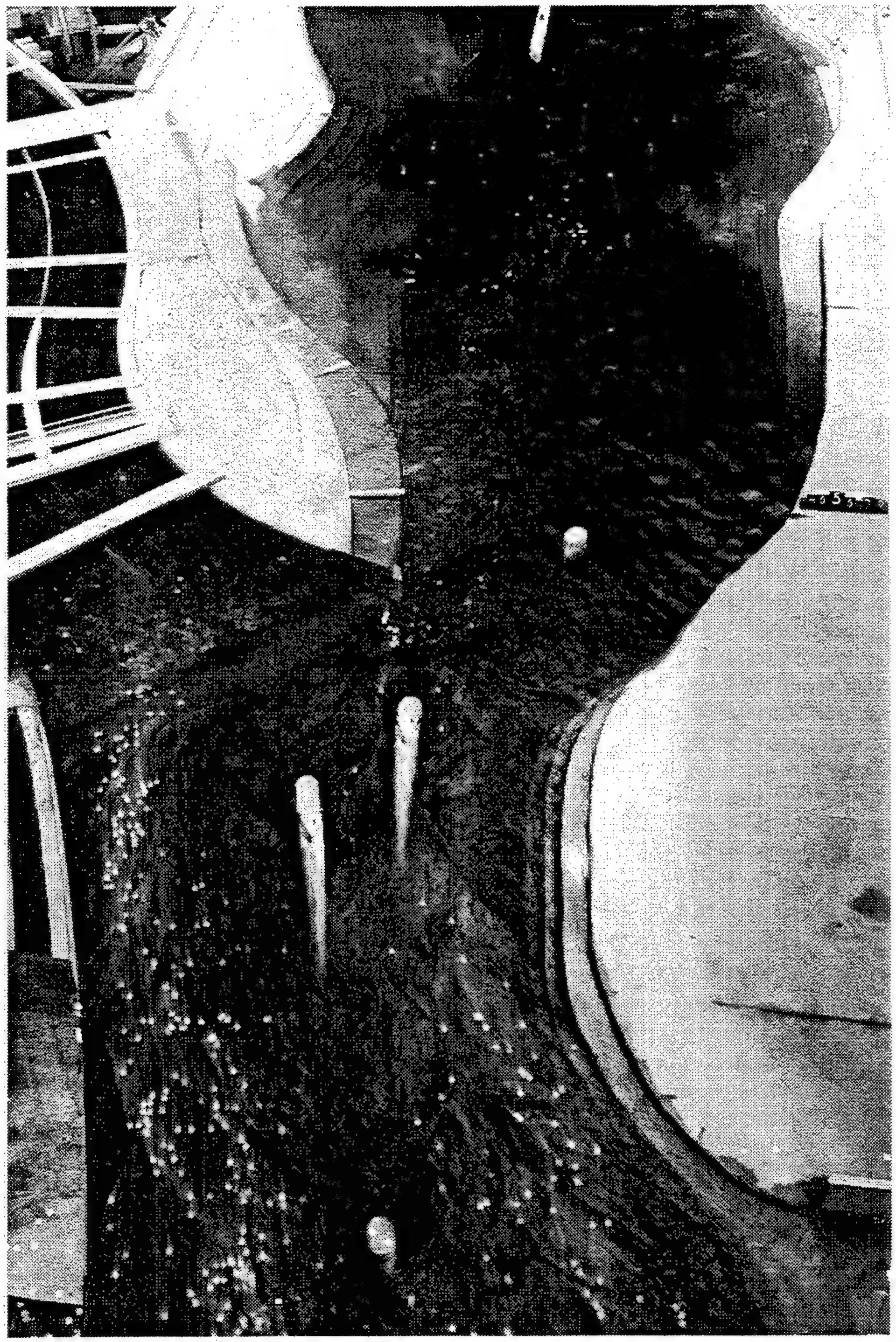


Photo 23. Looking downstream at flow conditions in the vicinity of the bypass entrance with the type 19 upstream channel, type 16 bypass entrance, and type 8 pier extensions with future conditions and a discharge of 14,600 cfs

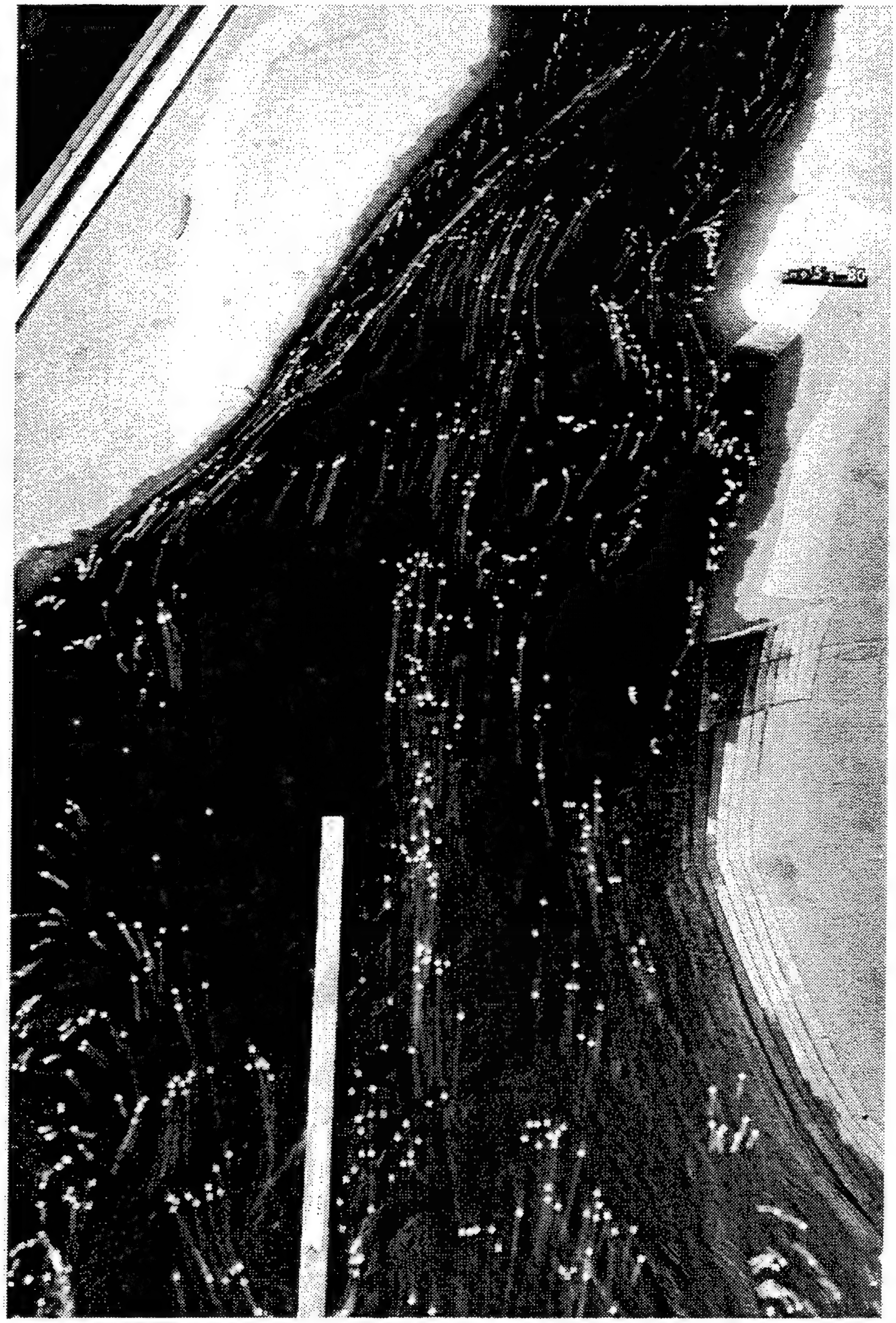


Photo 24. Looking downstream at flow conditions near the Woz Way Bridge with the type 19 upstream channel, type 16 bypass entrance, and type 8 pier extensions with future conditions and a total inflow of 14,600 cfs

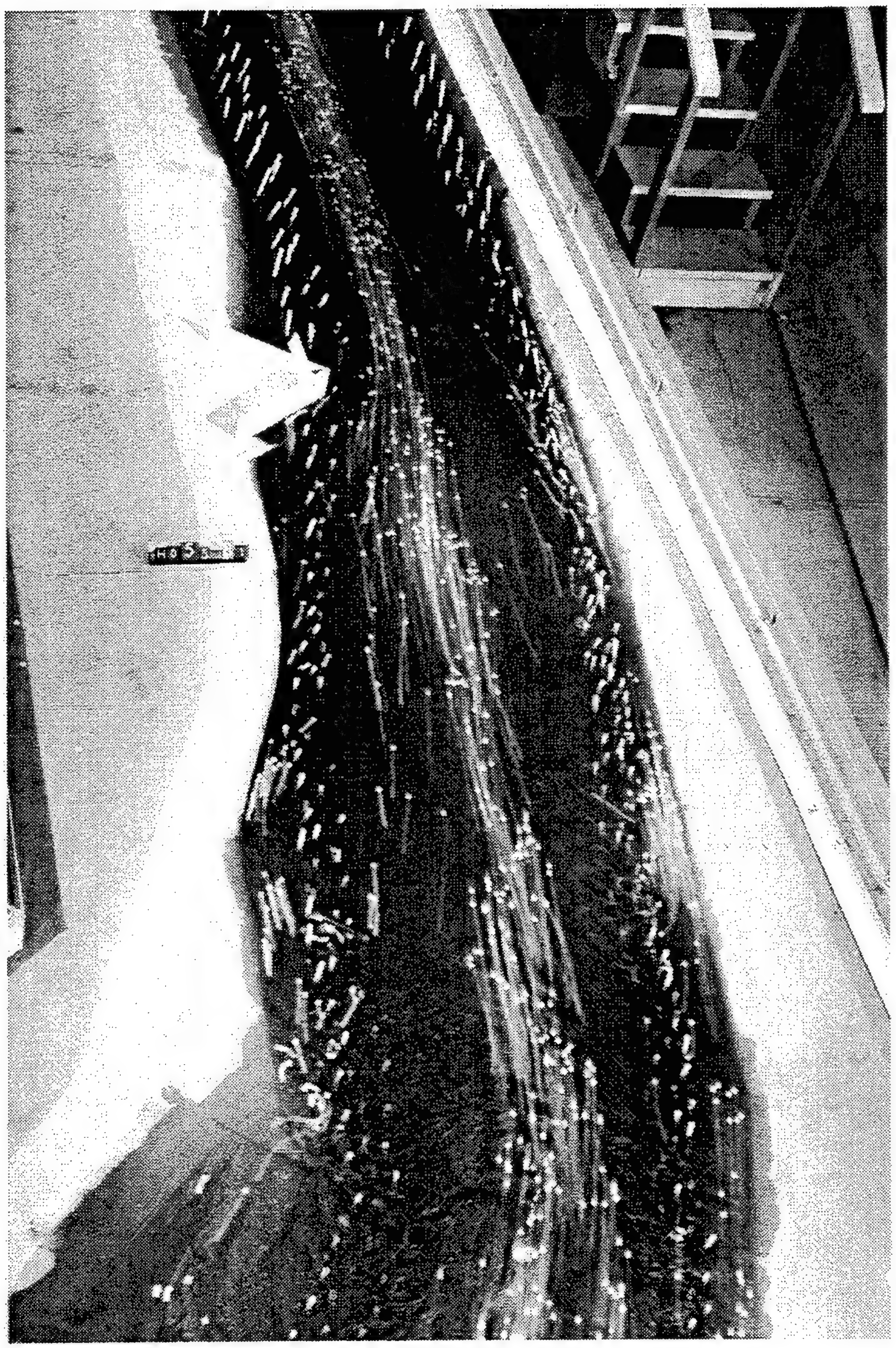


Photo 25. Looking downstream at flow conditions in the Guadalupe River between sta 185+00 and sta 180+00 near Auzerais Point with the type 19 upstream channel, type 16 bypass entrance, and type 8 pier extensions with future conditions and a total inflow of 14,600 cfs

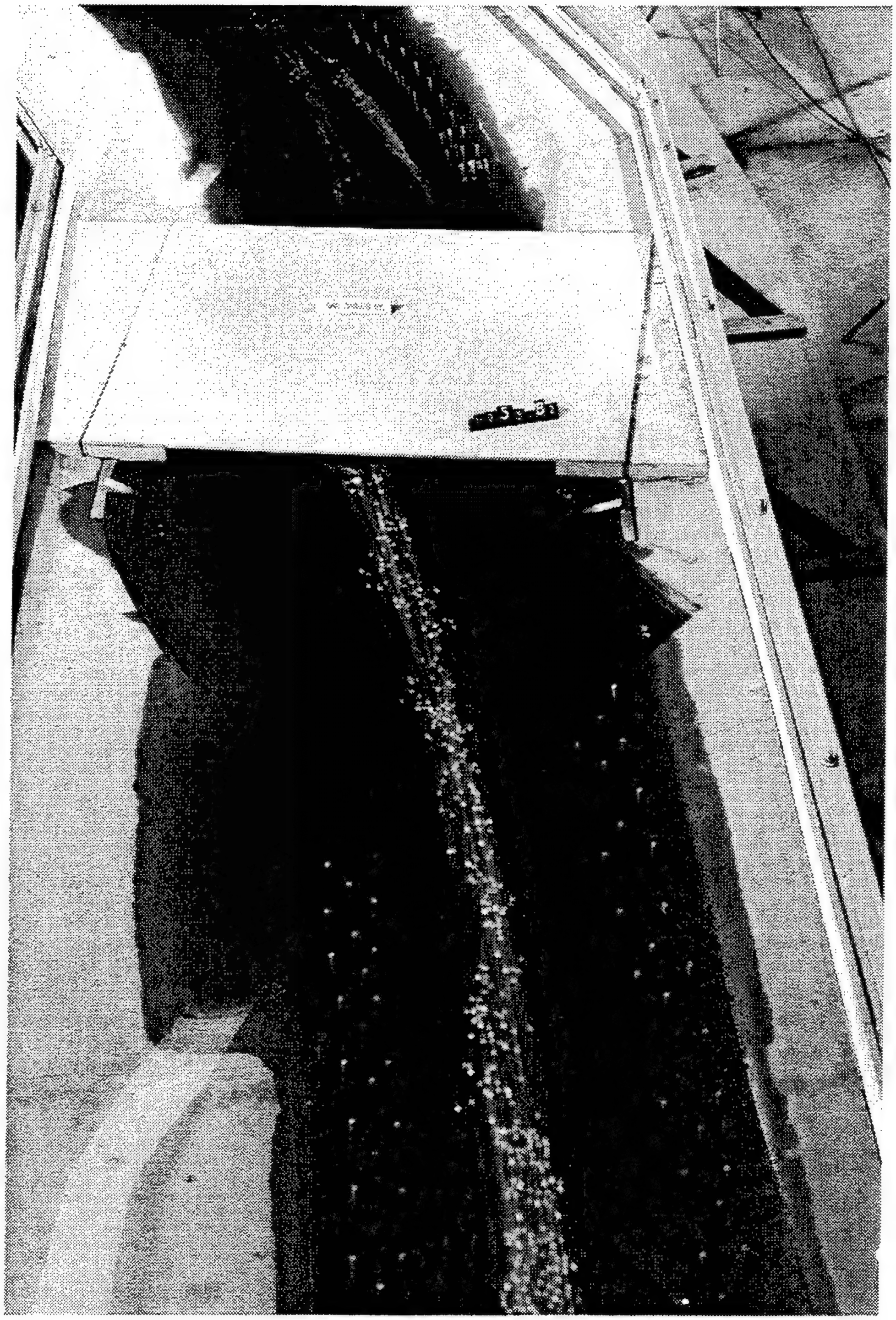


Photo 26. Looking downstream at flow conditions in the Guadalupe River in the vicinity of San Carlos St. Bridge with the type 19 upstream channel, type 16 bypass entrance, and type 8 pier extensions with future conditions and a total inflow of 14,600 cfs

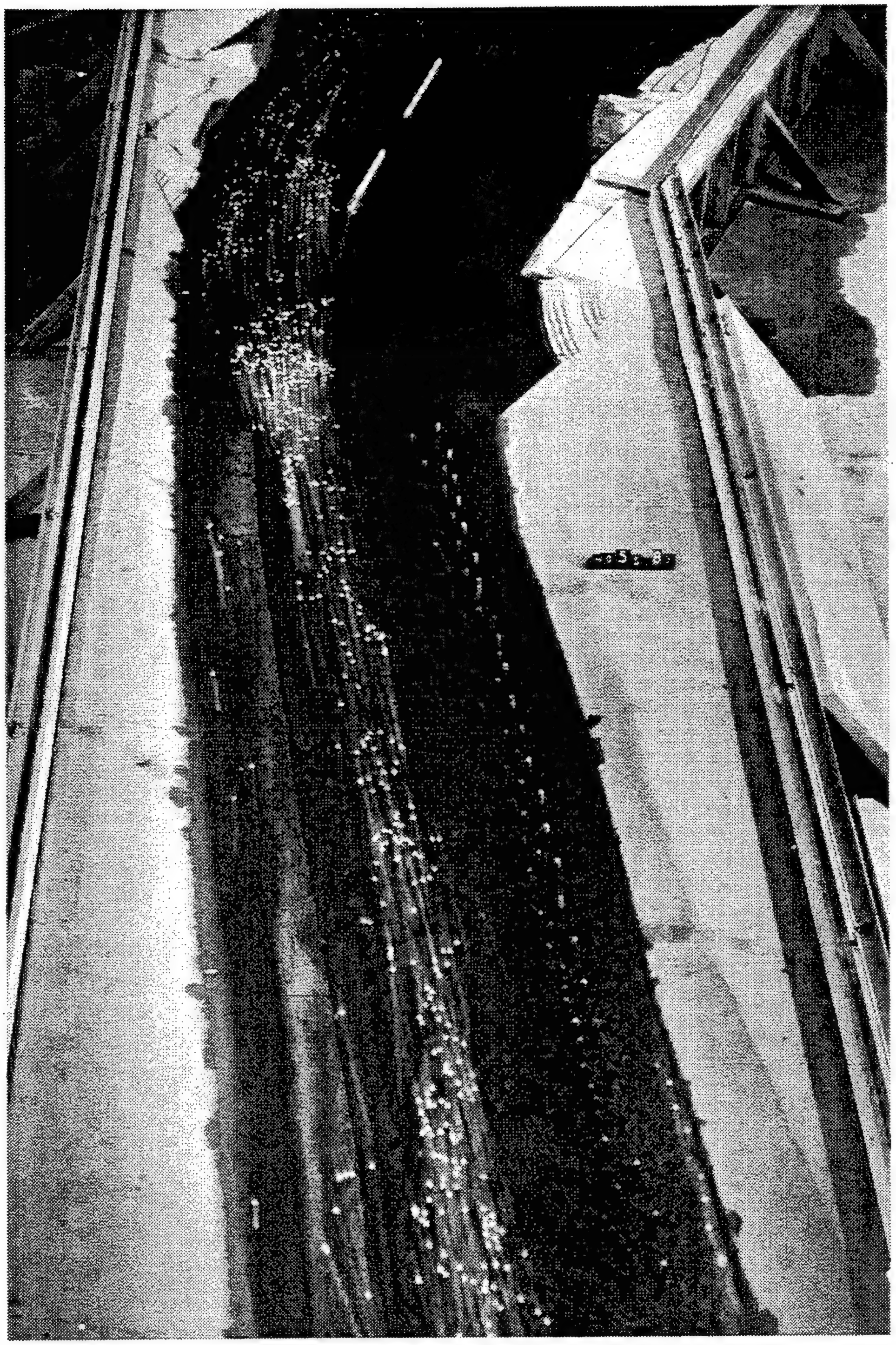


Photo 27. Looking downstream at flow conditions in the Guadalupe River between the San Carlos St. and Park Ave. Bridges with the type 19 upstream channel, type 16 bypass entrance, and type 8 pier extensions with future conditions and a total inflow of 14,600 cfs

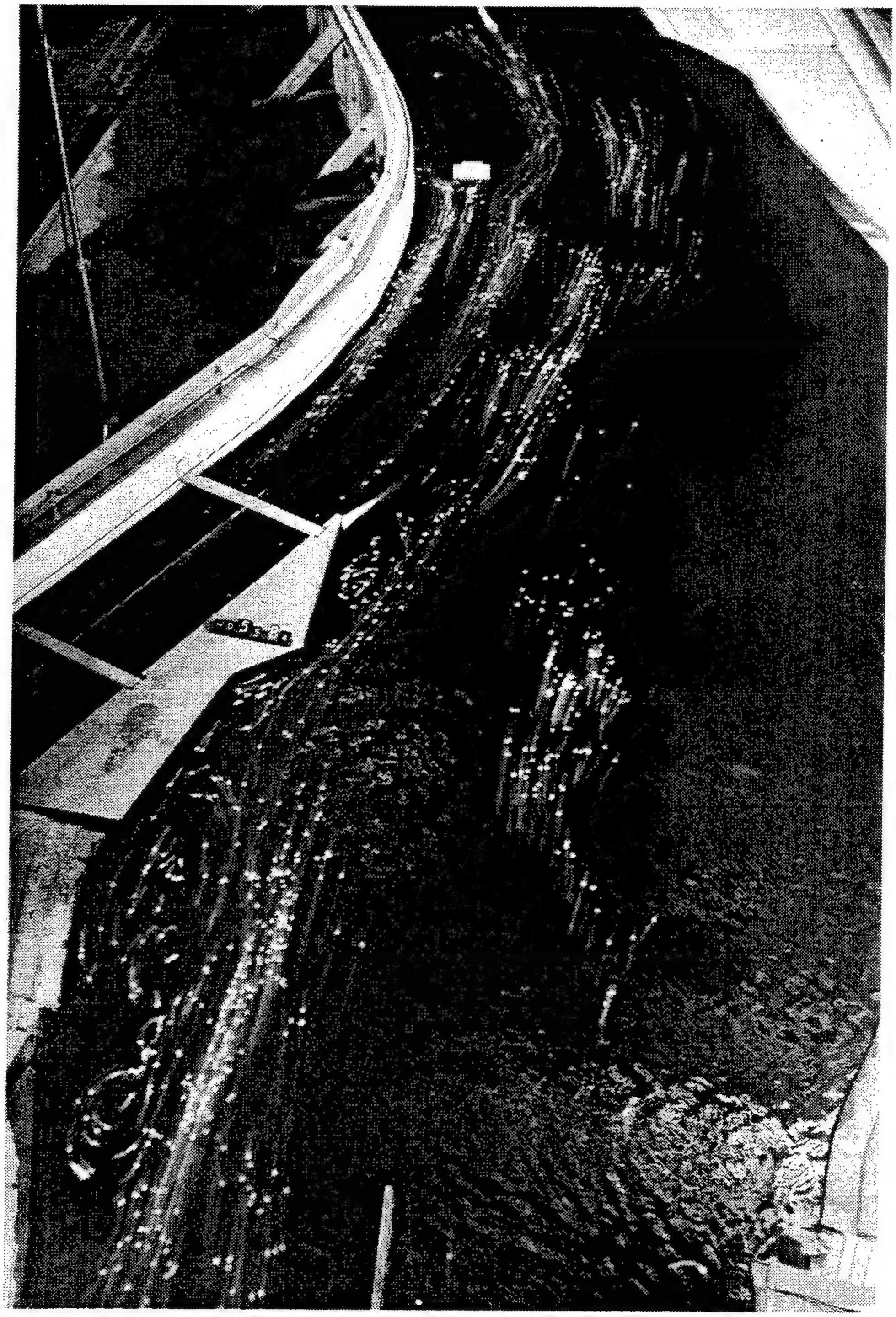


Photo 28. Looking downstream at flow conditions in the Guadalupe River from the Park Ave. Bridge to the confluence with the type 19 upstream channel, type 16 bypass entrance, and type 8 pier extensions with future conditions and a discharge of 14,600 cfs

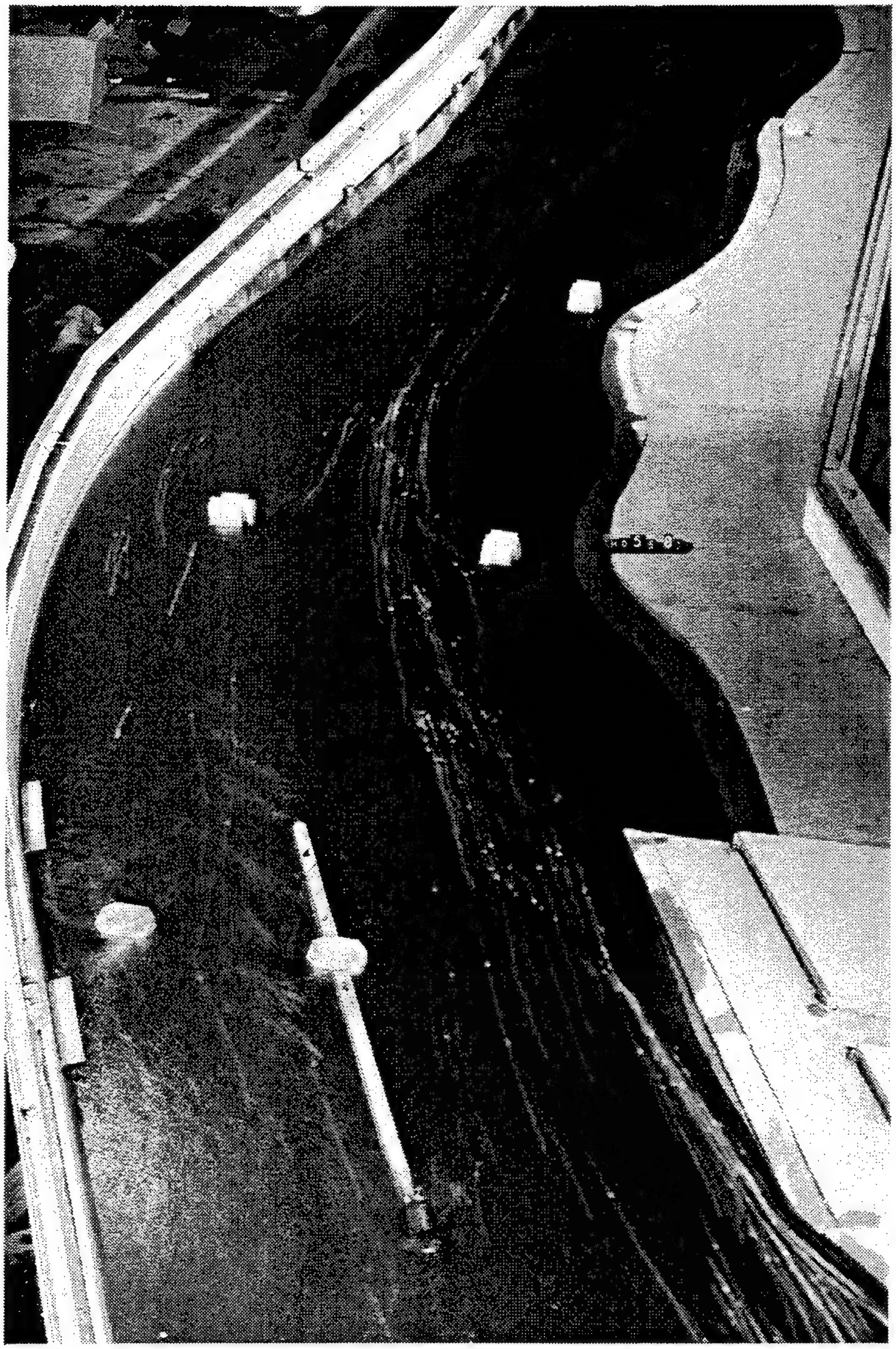


Photo 29. Looking downstream at flow conditions in the Guadalupe River near the San Fernando St. Bridge with the type 19 upstream channel, type 16 bypass entrance, and type 8 pier extensions with future conditions and a discharge of 14,600 cfs

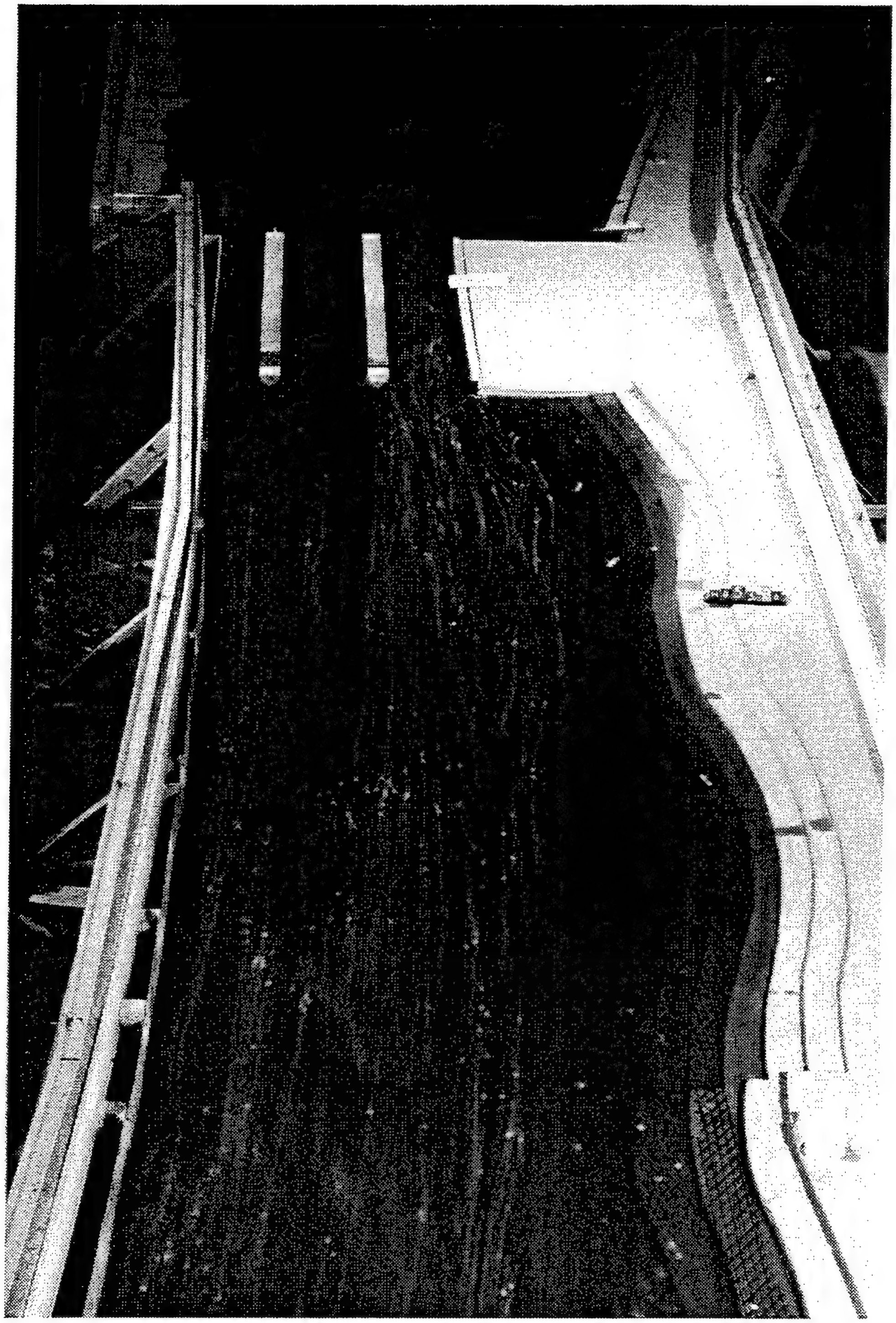
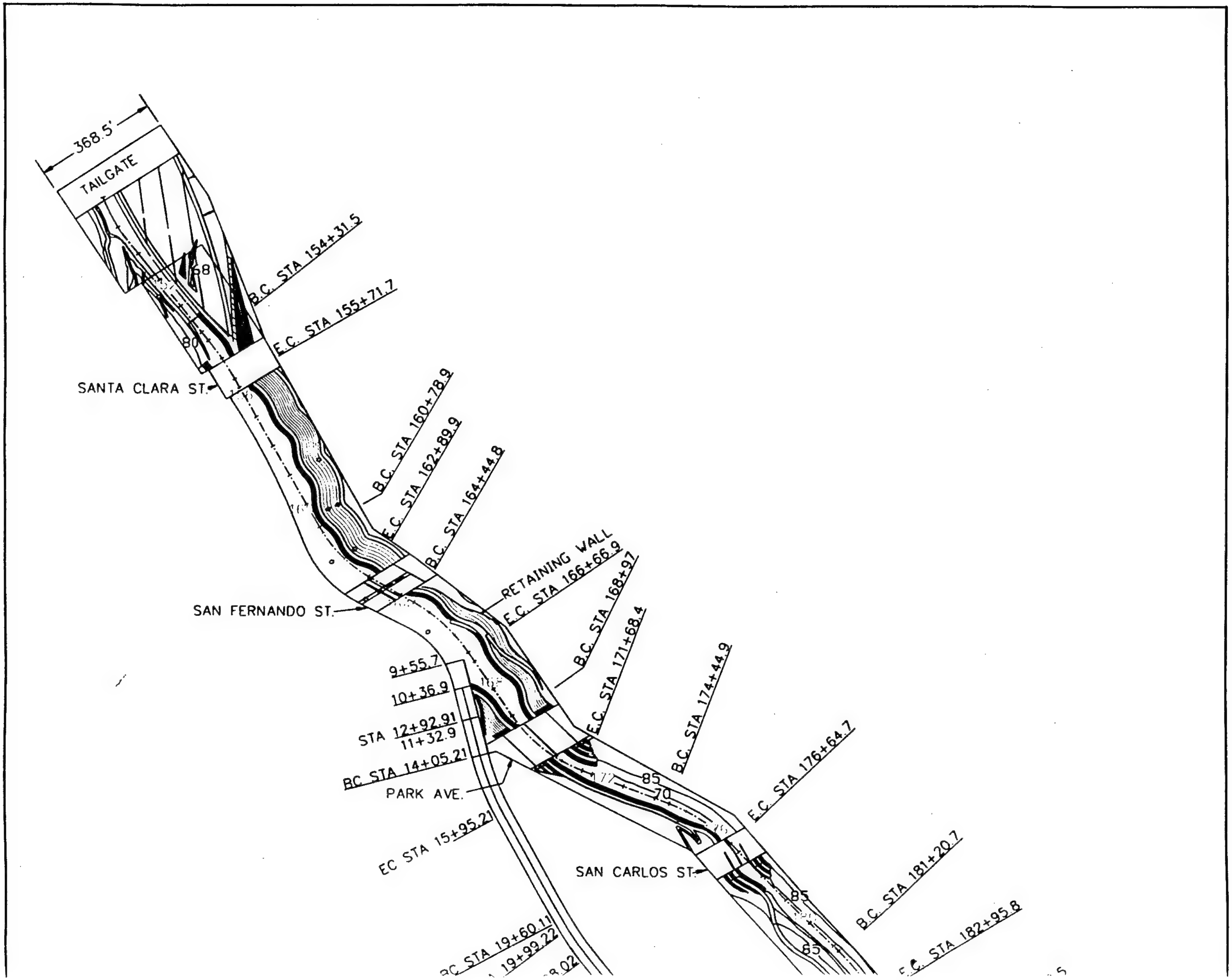
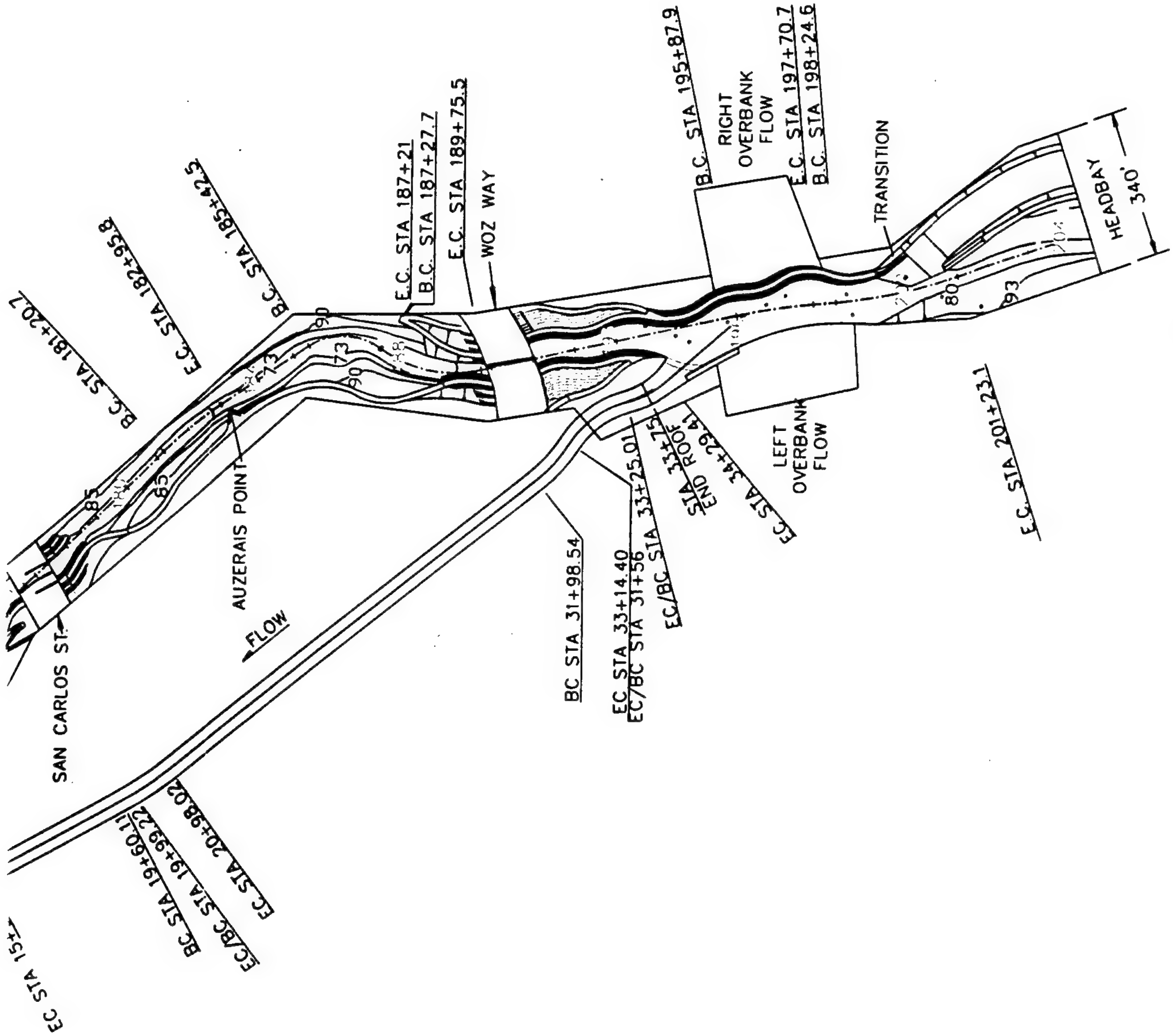


Photo 30. Looking downstream at flow conditions in the Guadalupe River near the Santa Clara St. Bridge with the type 19 upstream channel, type 16 bypass entrance, and type 8 pier extensions with future conditions and a discharge of 14,600 cfs

1

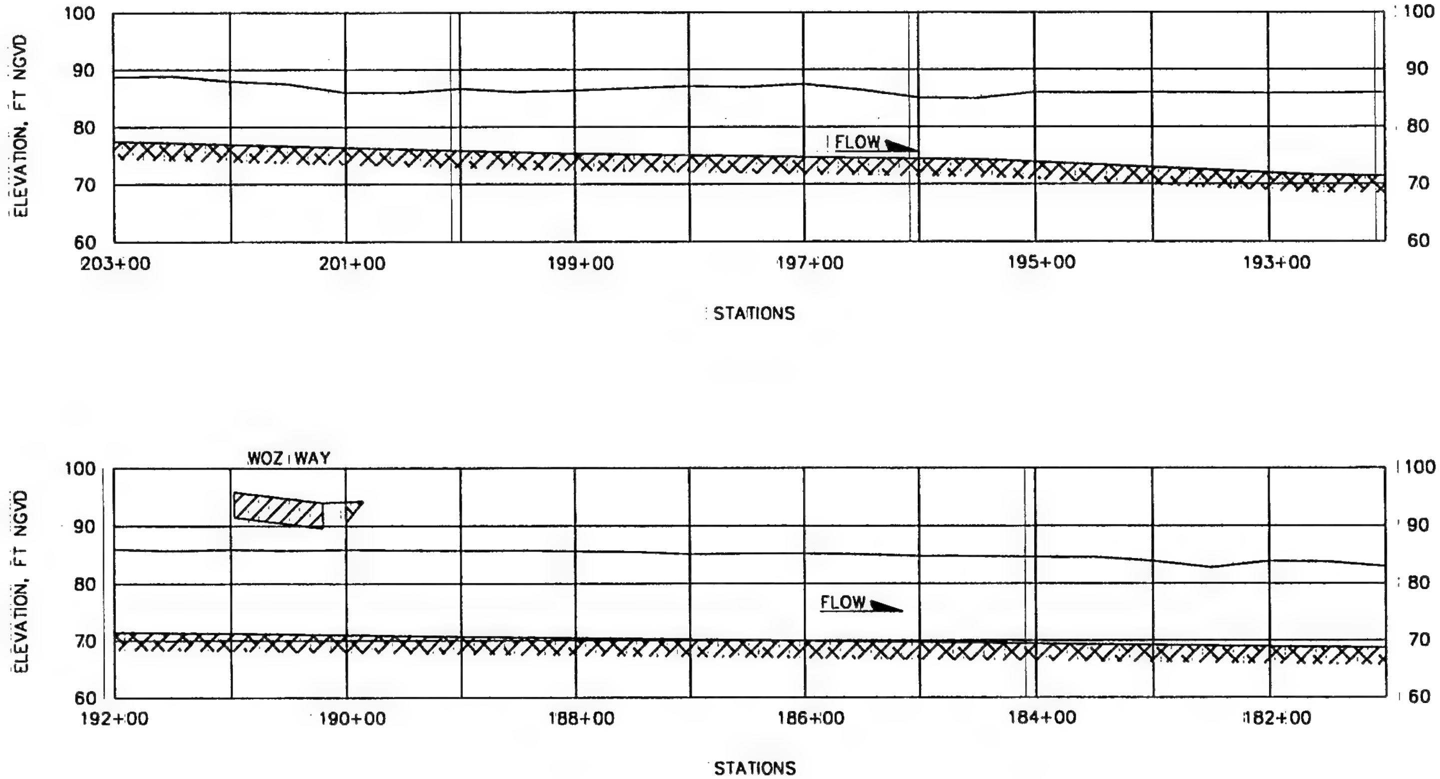

368.5'
TAILGATE
B.C. STA 154+31.5
E.C. STA 155+71.7
SANTA CLARA ST.
B.C. STA 160+78.9
E.C. STA 162+89.9
B.C. STA 164+44.8
SAN FERNANDO ST.
RETAINING WALL
E.C. STA 166+66.9
B.C. STA 168+97
E.C. STA 171+68.4
B.C. STA 174+44.9
9+55.7
10+36.9
STA 12+92.91
11+32.9
BC STA 14+05.21
PARK AVE.
EC STA 15+95.21
E.C. STA 176+64.7
SAN CARLOS ST.
B.C. STA 181+20.7
E.C. STA 182+95.8
BC STA 19+60.11
19+99.22



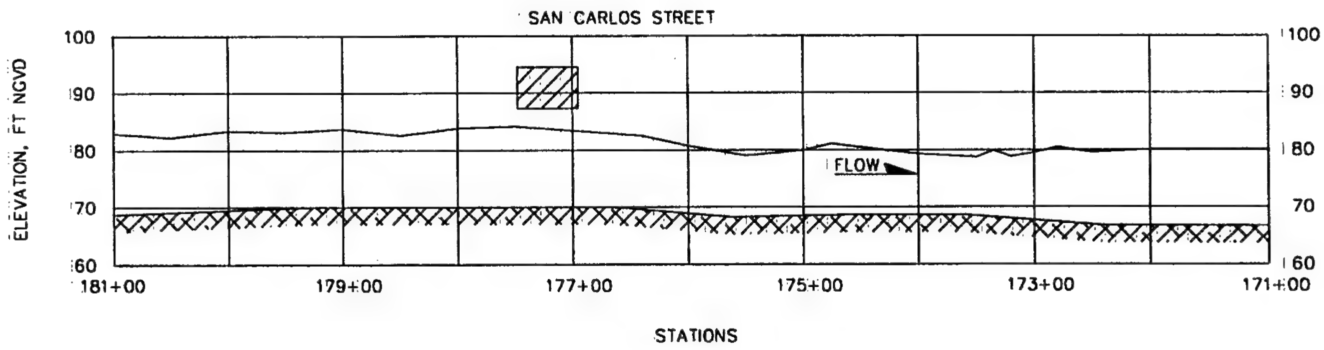

MODEL LAYOUT
GUADALUPE RIVER AND
BYPASS CULVERT

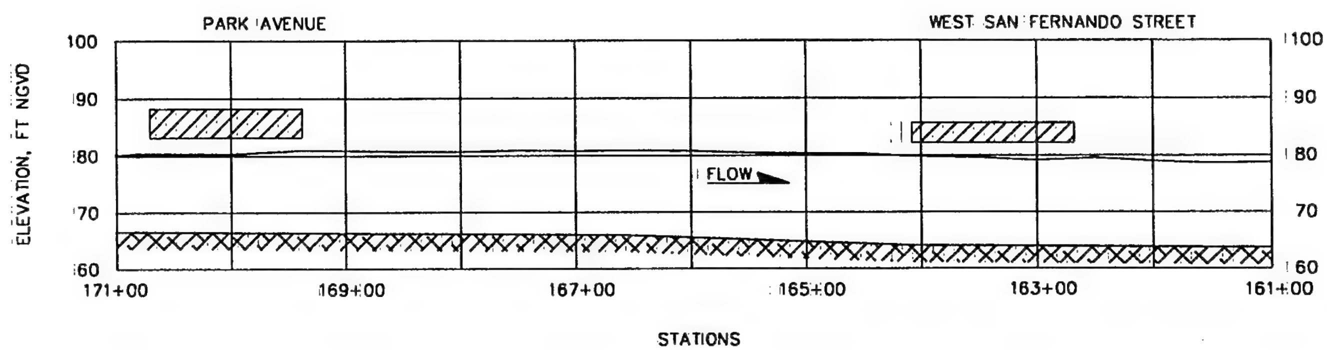


2

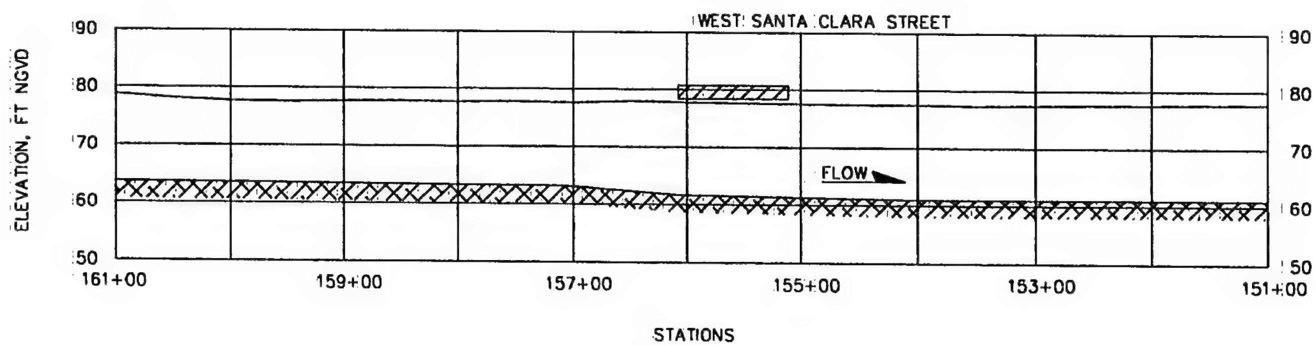



WATER-SURFACE PROFILES
STA 203+00 TO STA 181+00
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 114,600 CFS
WATER-SURFACE ELEVATION AT STA 151+27 = 77.6

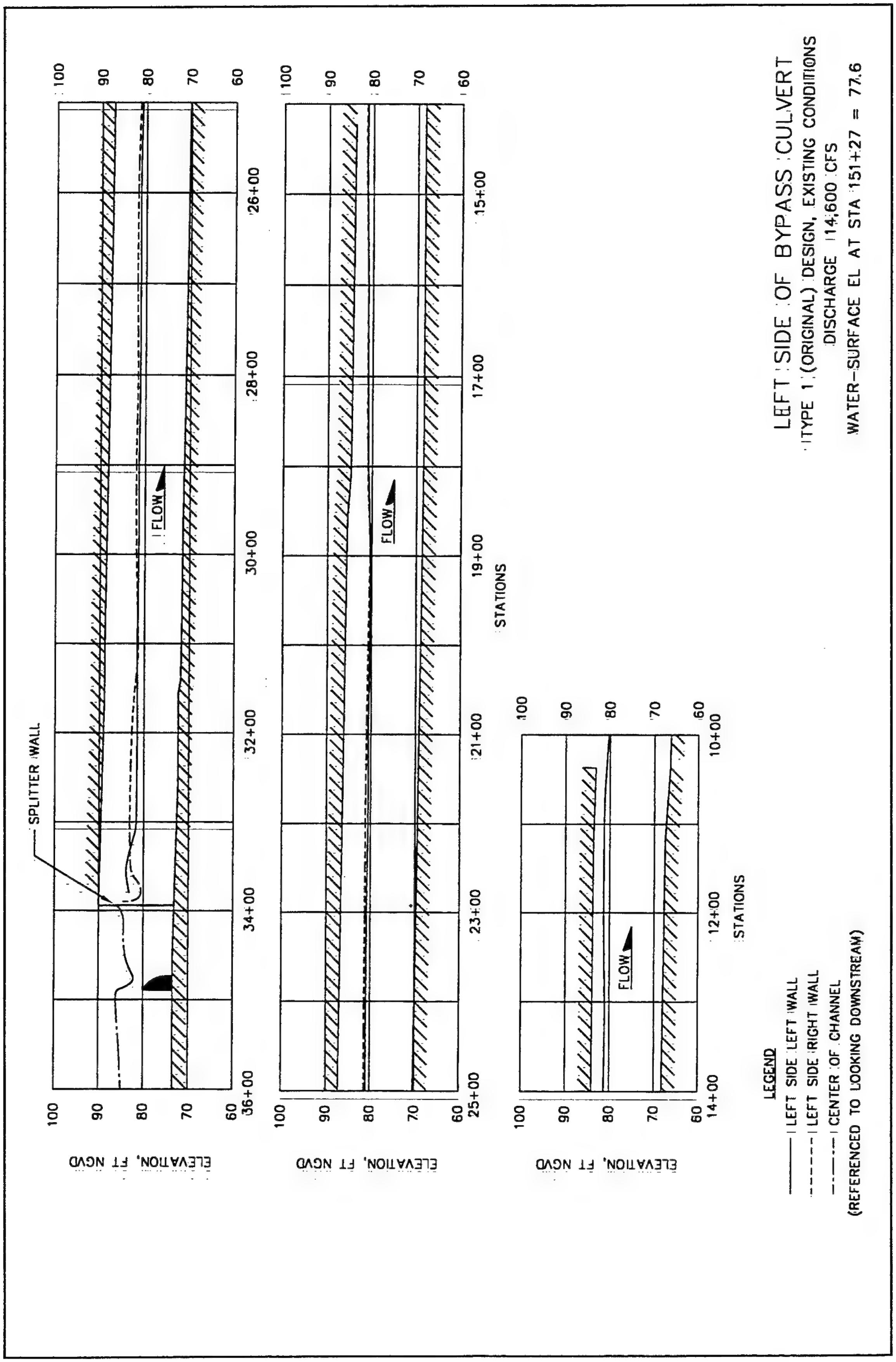


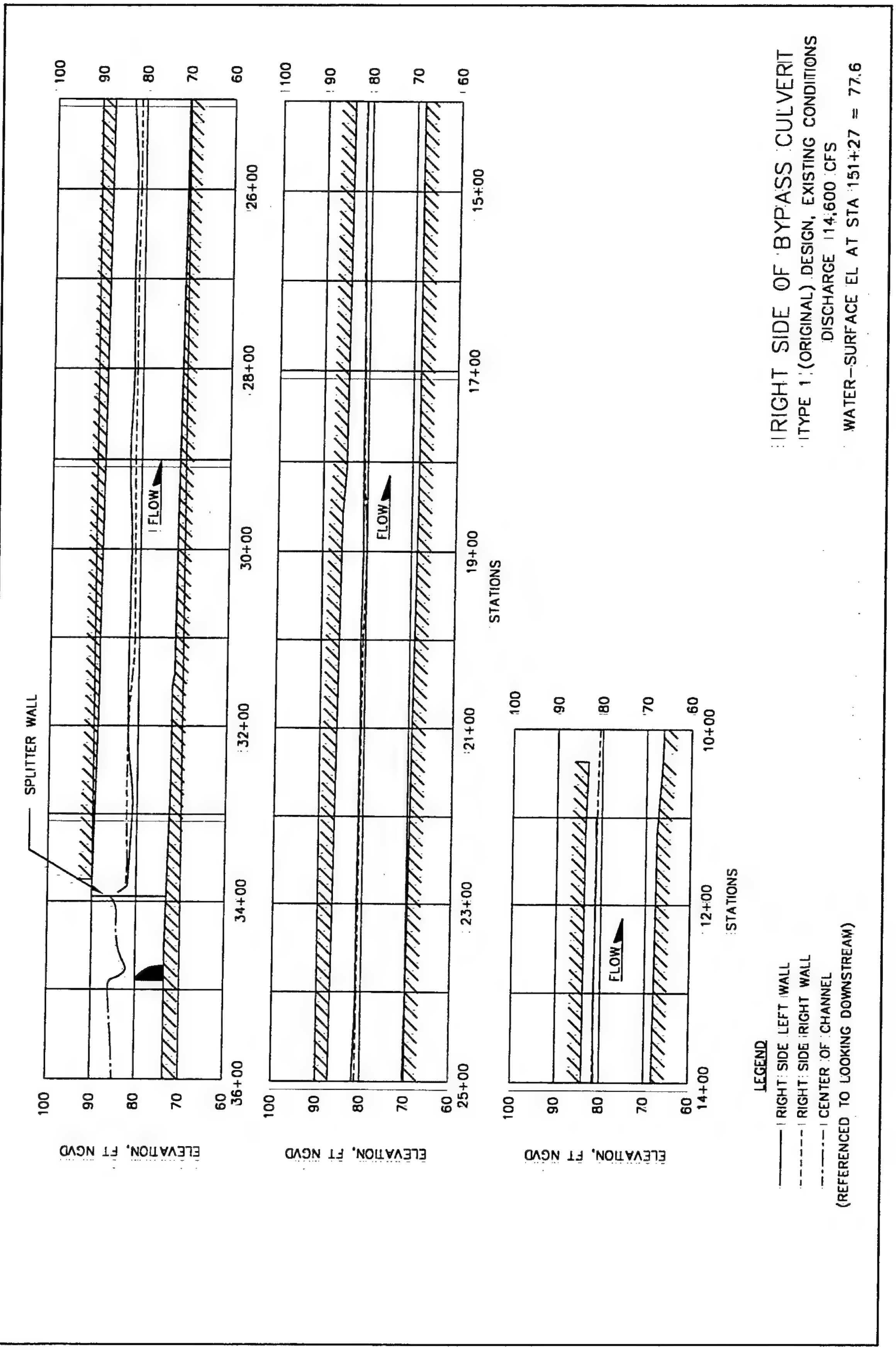



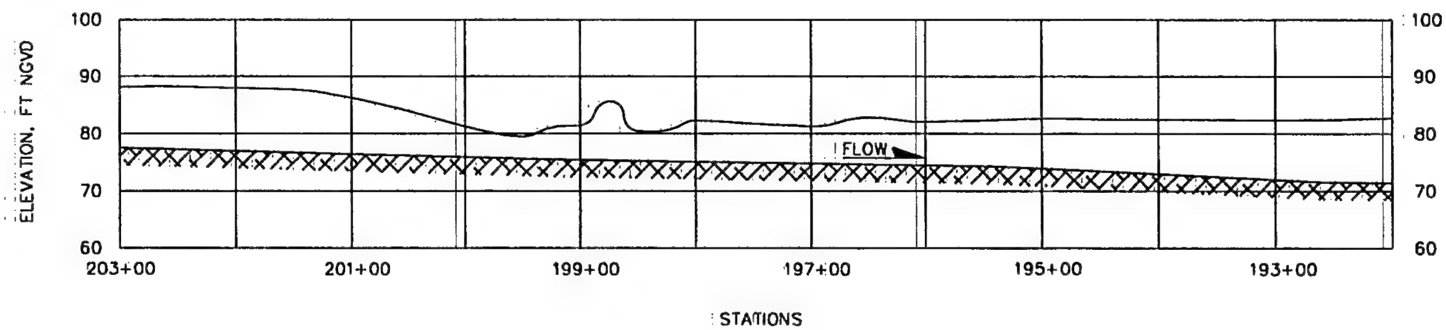

WATER-SURFACE PROFILES
STA 181+00 TO 161+00
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT STA 151+27 = 77.6

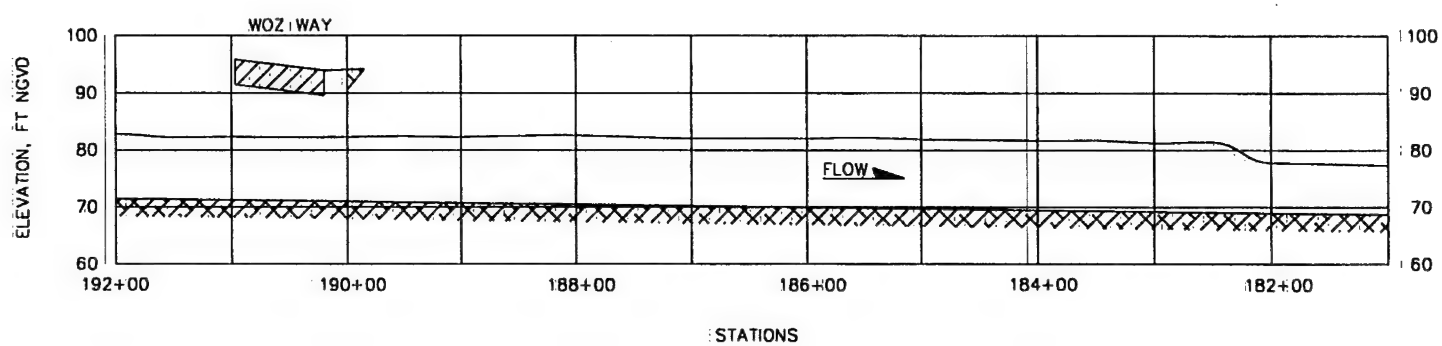



WATER-SURFACE PROFILES
STA 161+00 TO STA 151+00
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT STA 151+27 = 77.6

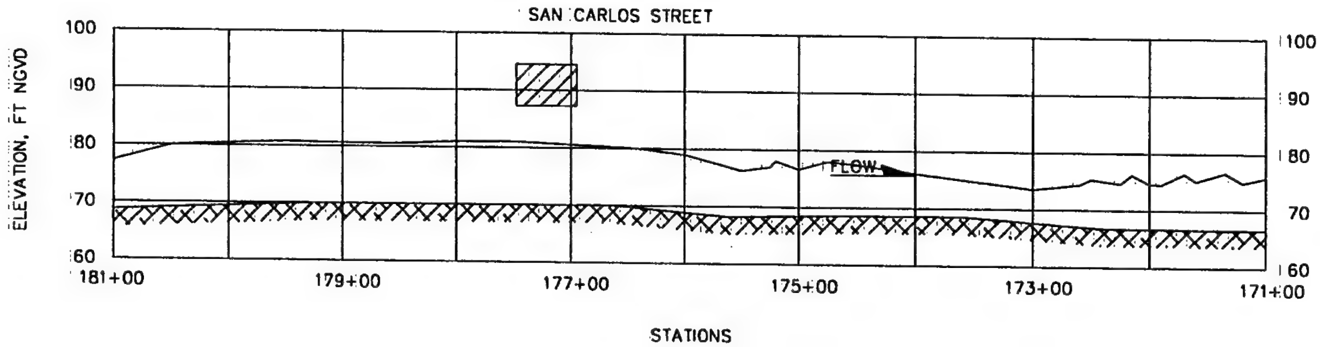

LEFT SIDE OF BYPASS CULVERT
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE EL AT STA 151+27 = 77.6
SPLITTER WALL
FLOW
ELEVATION, FT NGVD
STATIONS
36+00
34+00
32+00
30+00
28+00
26+00
25+00
23+00
21+00
19+00
17+00
15+00
14+00
12+00
10+00
100
90
80
70
60
LEGEND
LEFT SIDE LEFT WALL
LEFT SIDE RIGHT WALL
CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)

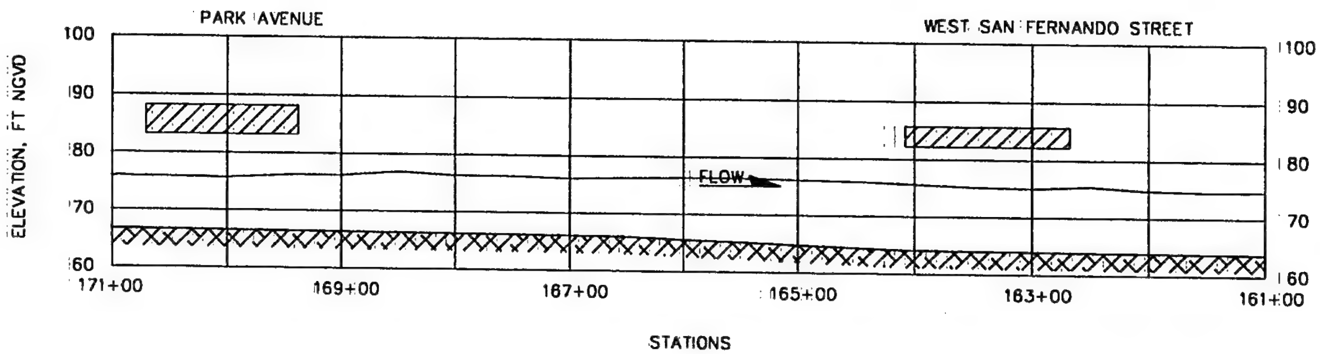

RIGHT SIDE OF BYPASS CULVERT
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 114,600 CFS
WATER-SURFACE EL AT STA 151+27 = 77.6
SPLITTER WALL
FLOW
ELEVATION, FT NGVD
STATIONS
36+00
34+00
32+00
30+00
28+00
26+00
25+00
23+00
21+00
19+00
17+00
15+00
14+00
12+00
10+00
100
90
80
70
60
LEGEND
RIGHT SIDE LEFT WALL
RIGHT SIDE RIGHT WALL
CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)



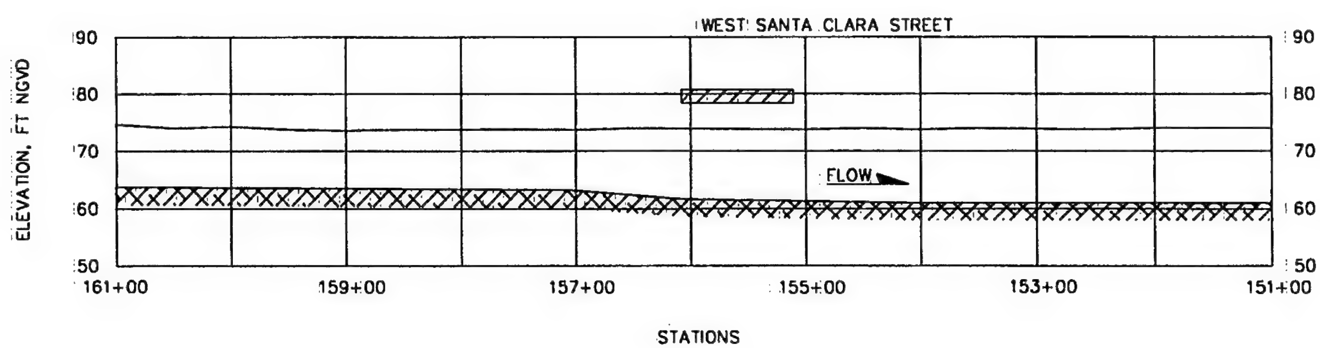




WATER-SURFACE PROFILES
STA 203+00 TO STA 181+00
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 9,100 CFS
WATER-SURFACE ELEVATION AT STA 151+27 = 73.9

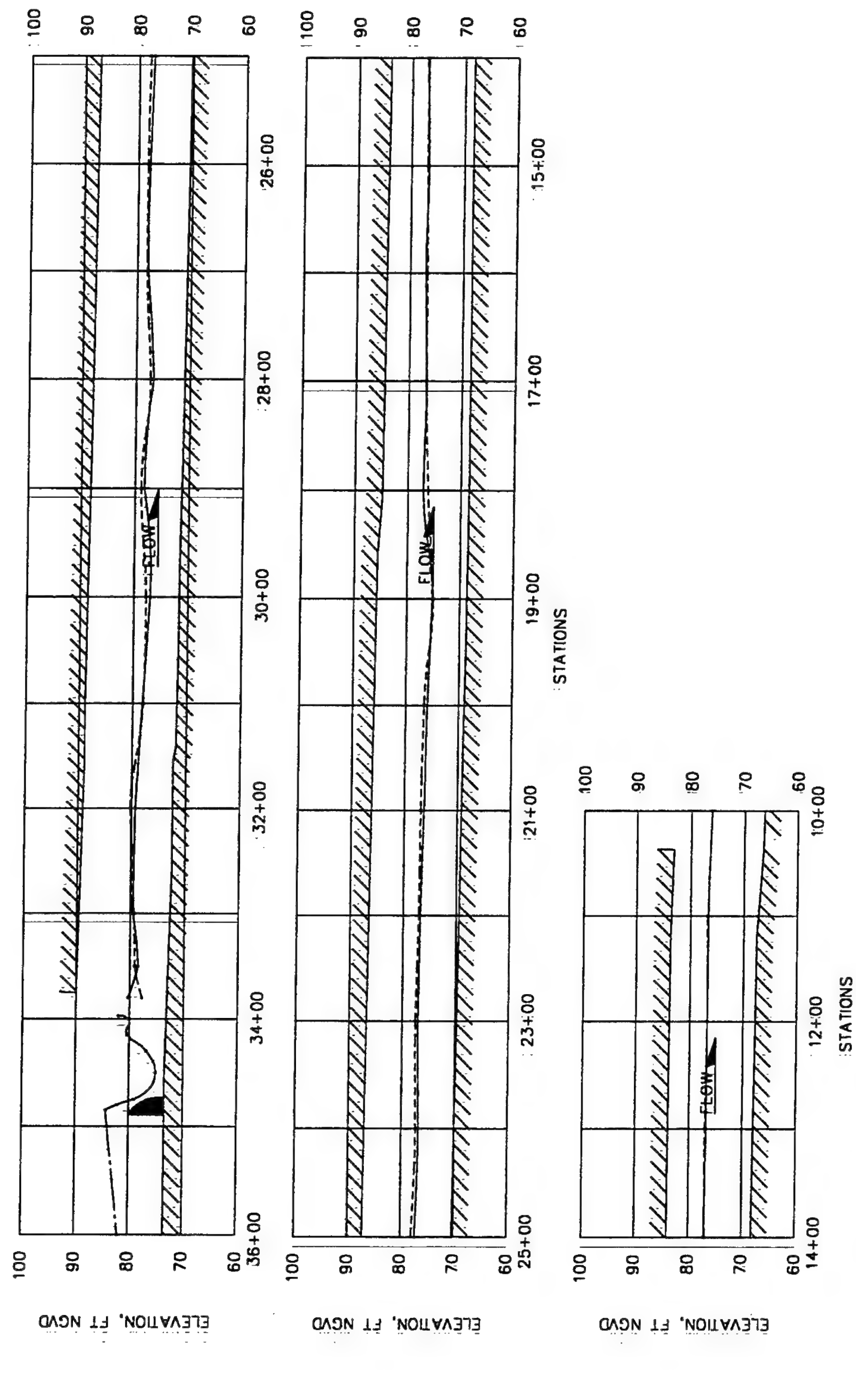


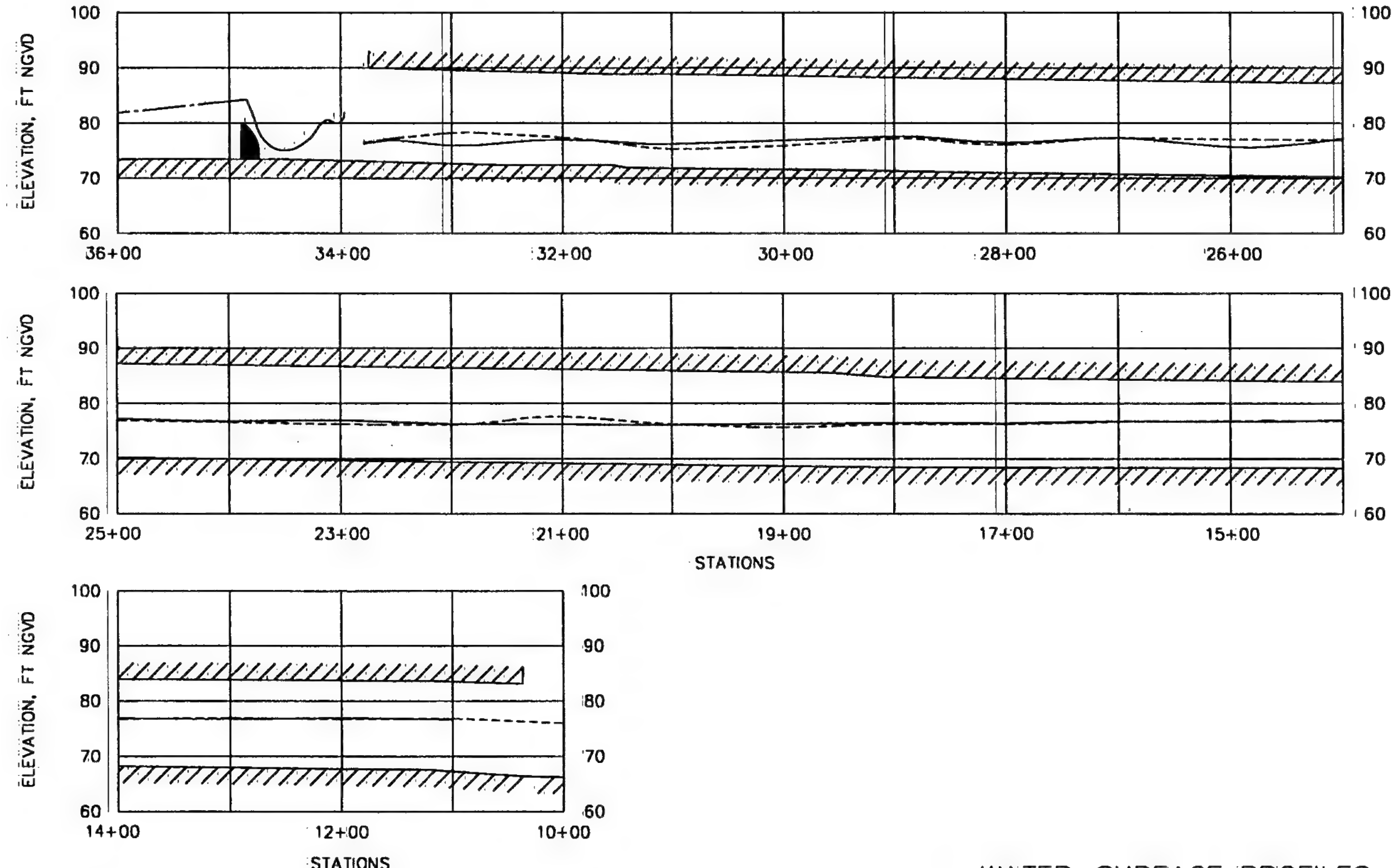

WATER-SURFACE PROFILES
STA 181+00 TO 161+00
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 9,100 CFS
WATER-SURFACE ELEVATION AT STA 151+27 = 73.9




WATER-SURFACE PROFILES
STA 161+00 TO STA 151+00
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 9,100 CFS
WATER-SURFACE ELEVATION AT STA 151+27 = 73.9



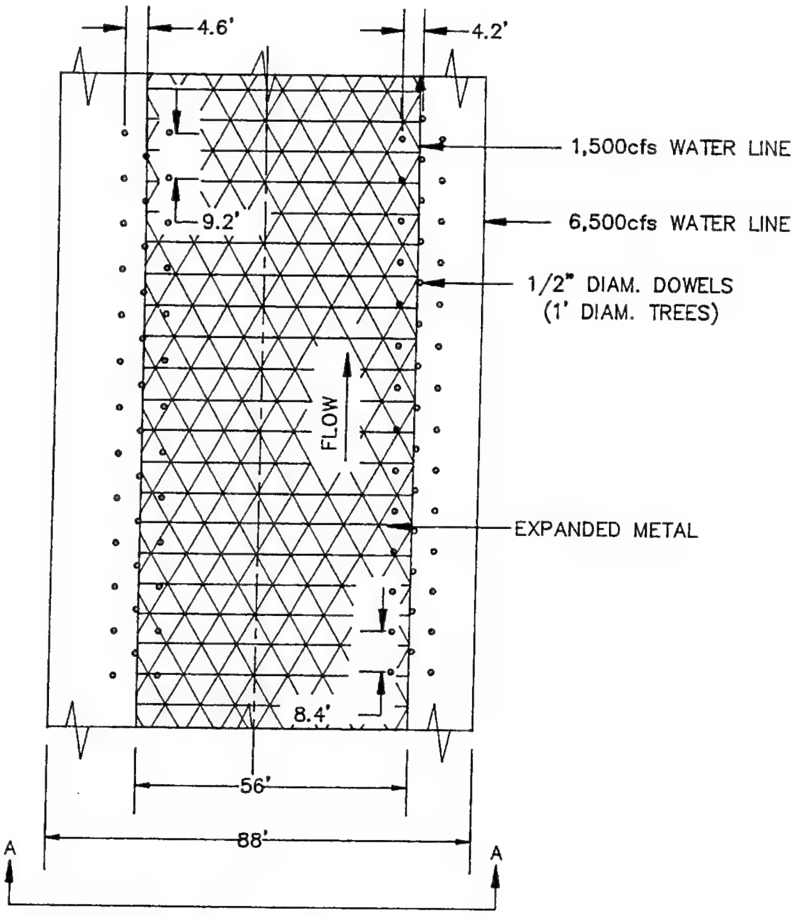

LEFT SIDE OF BYPASS CULVERT
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 9,100 CFS
WATER-SURFACE EL AT STA 151+27 = 73.9



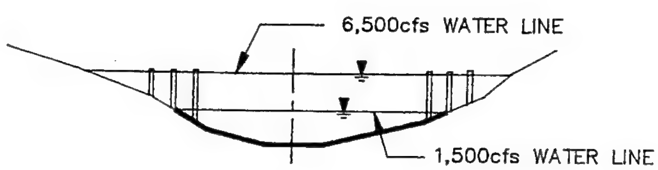

LEGEND

——— RIGHT SIDE LEFT WALL
- - - - - - RIGHT SIDE RIGHT WALL
—·—·— CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)

WATER-SURFACE PROFILES
RIGHT SIDE OF BYPASS CULVERT
TYPE 1 (ORIGINAL) DESIGN, EXISTING CONDITIONS
DISCHARGE 9,100 CFS
WATER-SURFACE EL AT STA 151+27 = 73.9



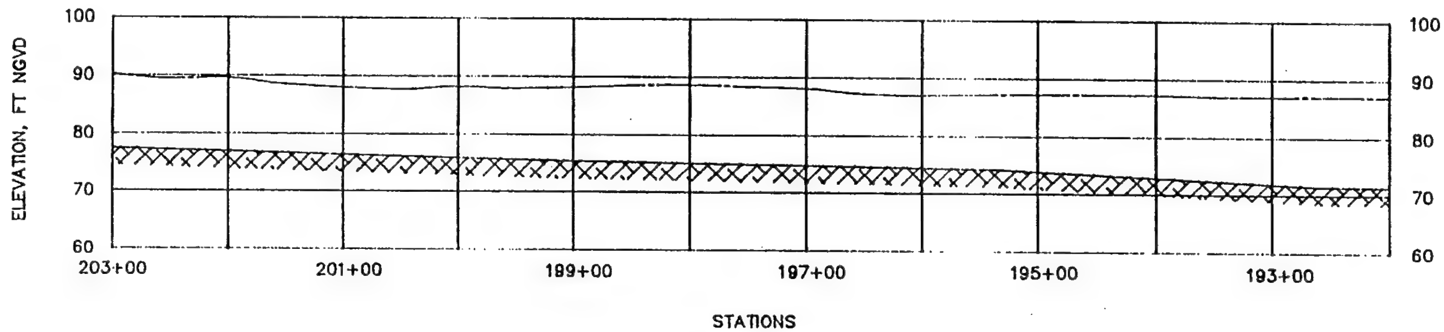

PLAN

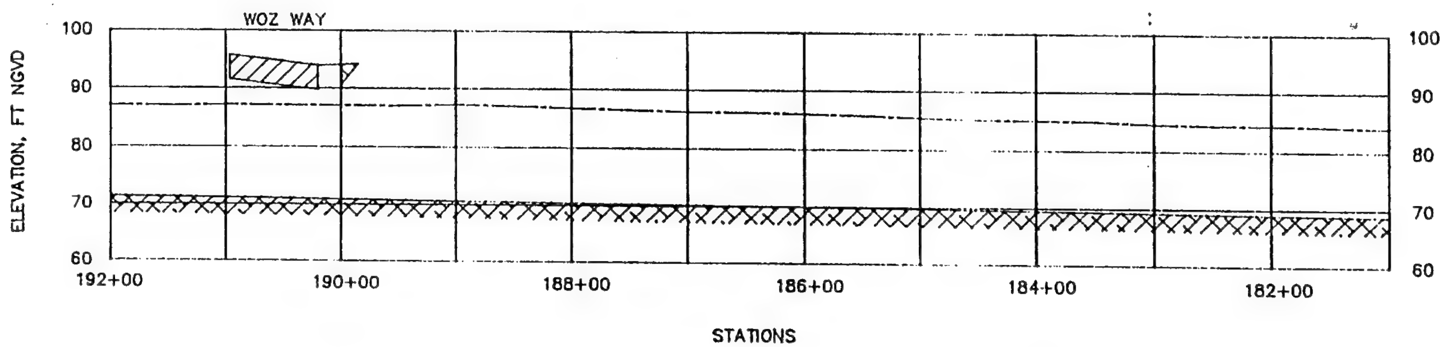



NOTE: PROTOTYPE n VALUE
AT 6500 cfs = 0.05

SECTION A – A

**DETAILS**
**ROUGHNESS MODEL**

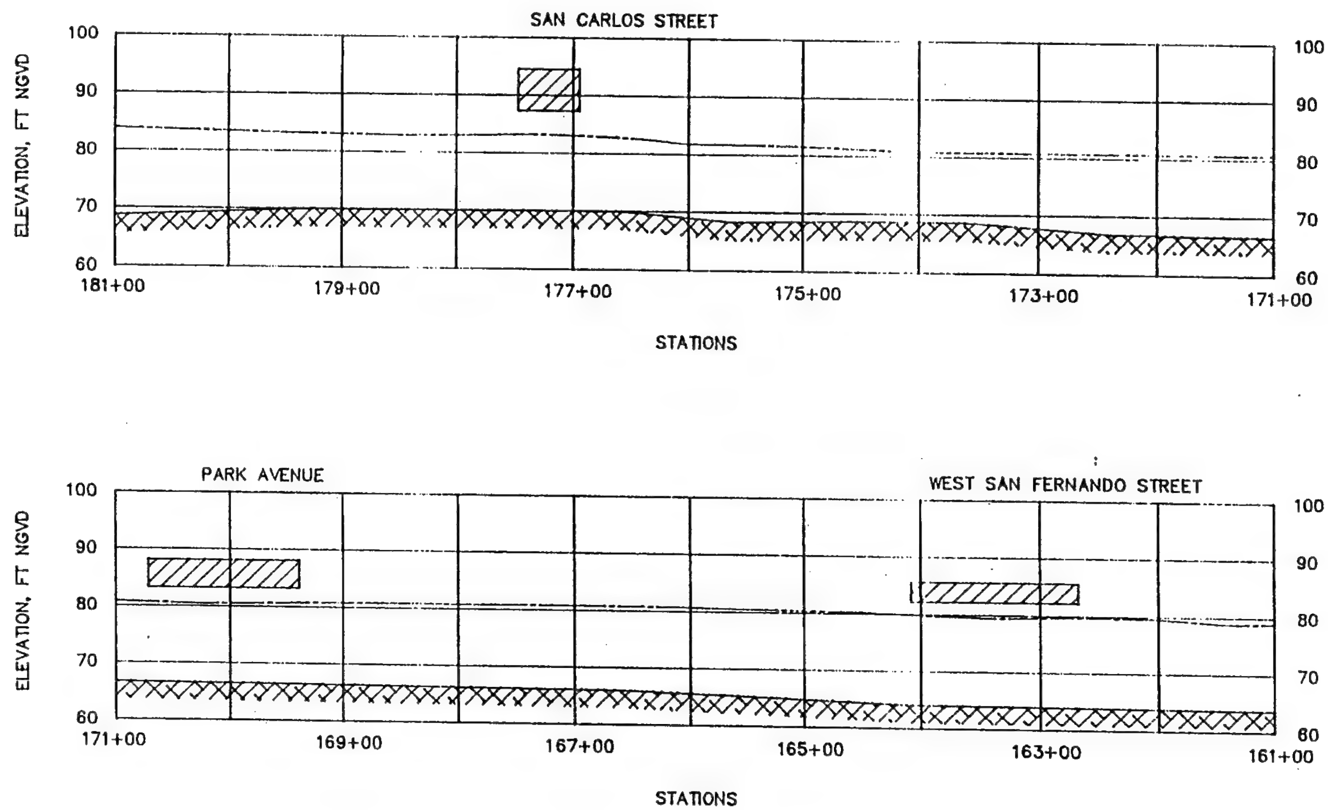



LEGEND

—·—·— CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)

**WATER-SURFACE PROFILES**
STA 203+00 TO STA 181+00
TYPE 2 DESIGN EXISTING CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT 151+27 = 77.6




LEGEND

-------- CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)

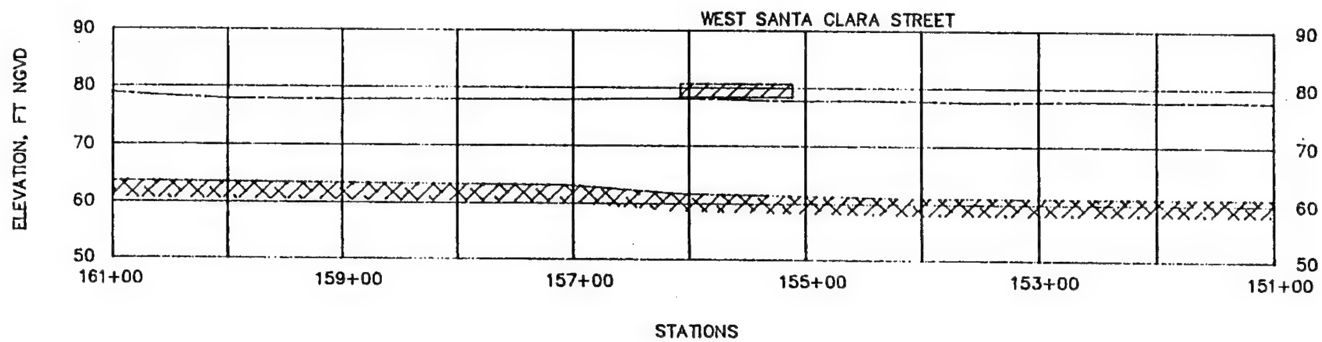
**WATER-SURFACE PROFILES**

STA 181+00 TO 161+00

TYPE 2 DESIGN EXISTING CONDITIONS

DISCHARGE 14,600 CFS

WATER-SURFACE ELEVATION AT STA 151+27 = 77.6




**LEGEND**

-·-·-·-·- CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)

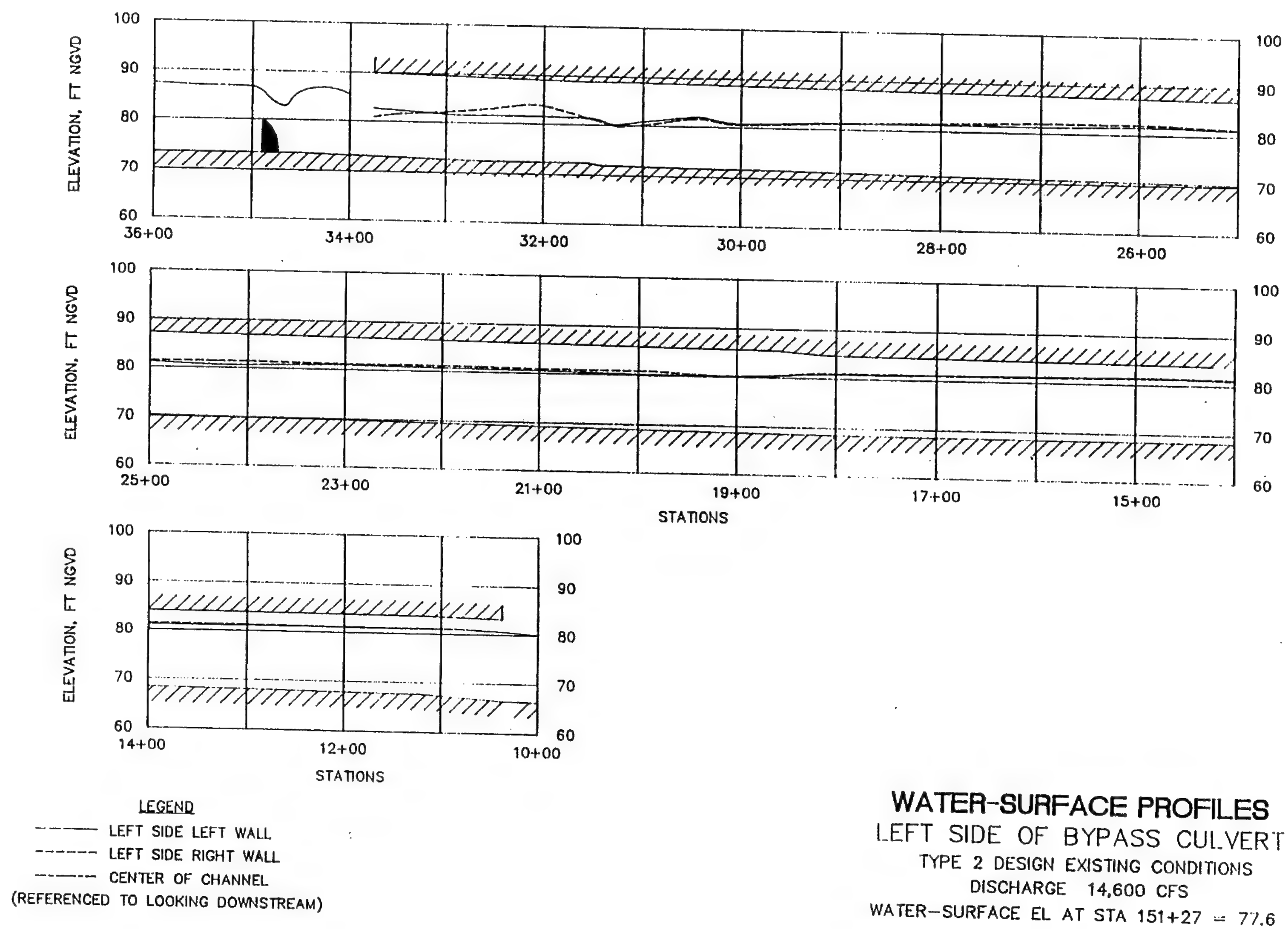
## WATER-SURFACE PROFILES

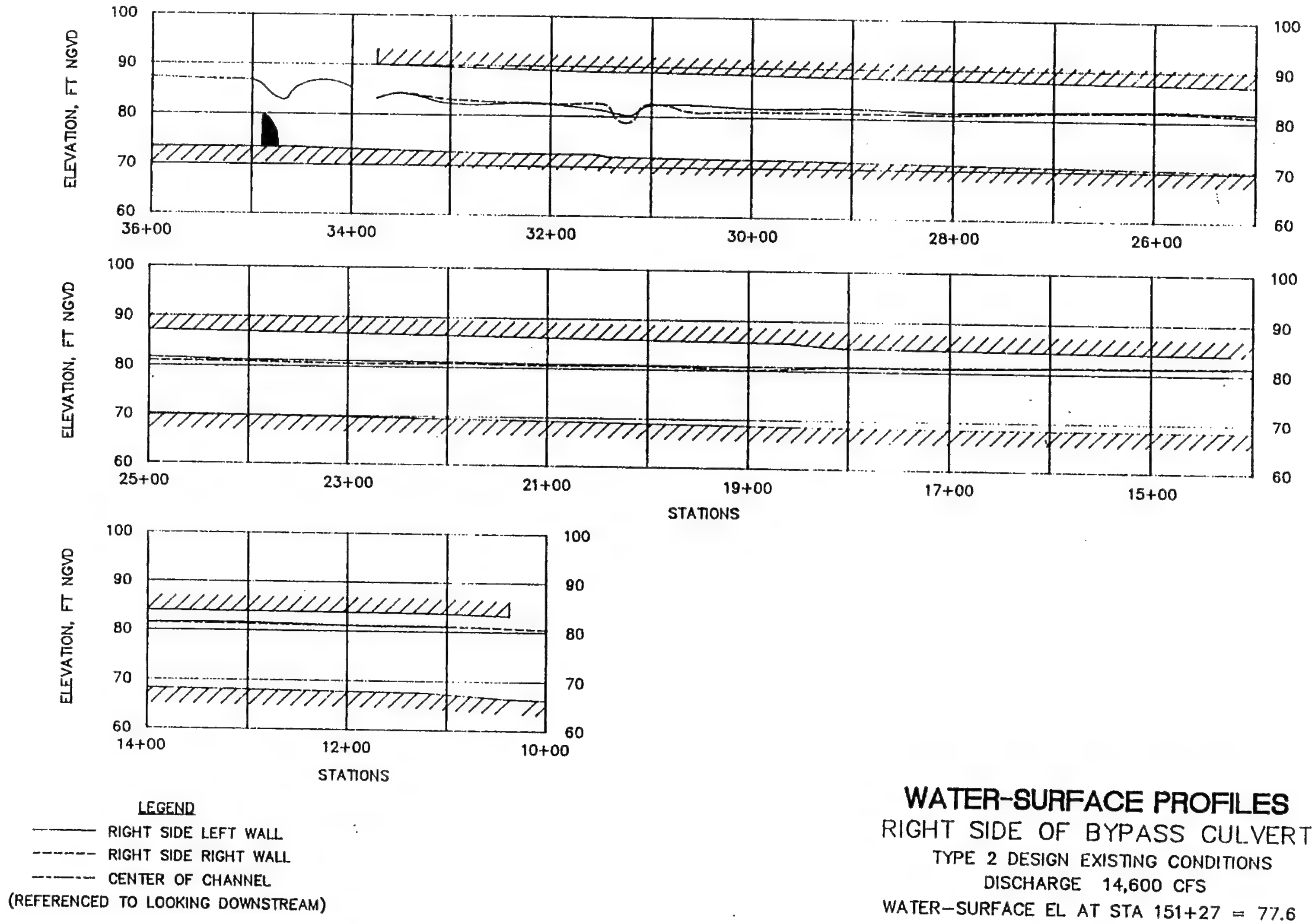
STA 161+00 TO STA 151+00

TYPE 2 EXISTING CONDTIONS

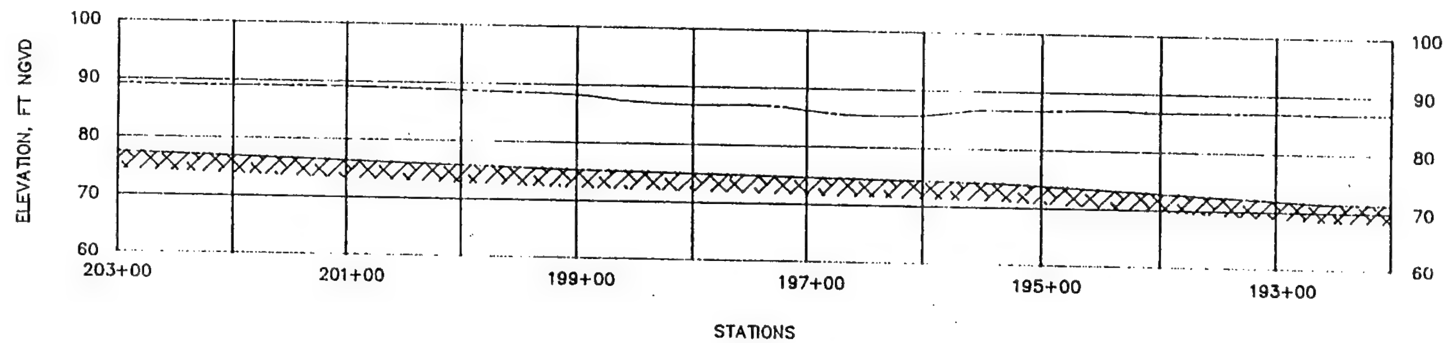
DISCHARGE 14,600 CFS

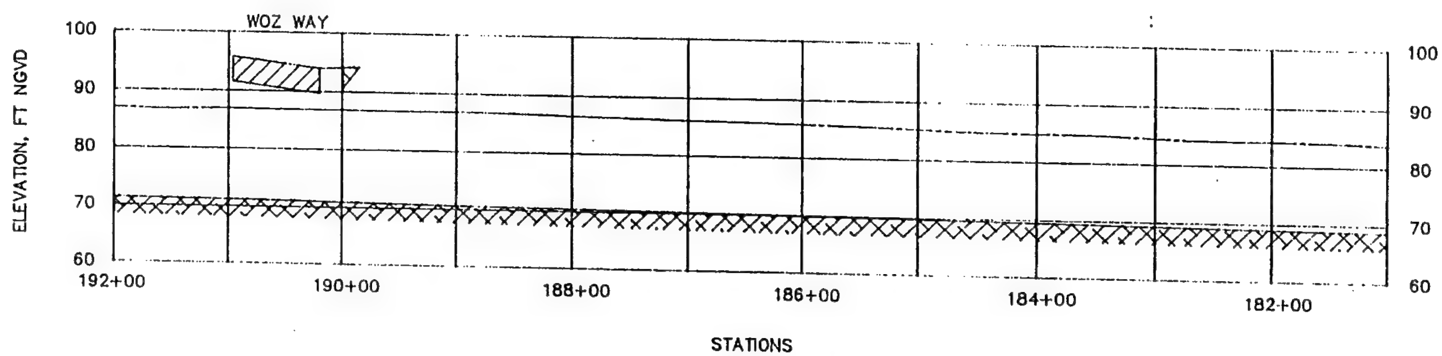
WATER-SURFACE ELEVATION AT STA 151+27 = 77.6


ELEVATION, FT NGVD
100
90
80
70
60
36+00
34+00
32+00
30+00
28+00
26+00
25+00
23+00
21+00
19+00
17+00
15+00
STATIONS
14+00
12+00
10+00
STATIONS
LEGEND
LEFT SIDE LEFT WALL
LEFT SIDE RIGHT WALL
CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)
WATER-SURFACE PROFILES
LEFT SIDE OF BYPASS CULVERT
TYPE 2 DESIGN EXISTING CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE EL AT STA 151+27 = 77.6




**WATER-SURFACE PROFILES**
RIGHT SIDE OF BYPASS CULVERT
TYPE 2 DESIGN EXISTING CONDITIONS
DISCHARGE 14,600 CFS
WATER–SURFACE EL AT STA 151+27 = 77.6




LEGEND

-------- CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)

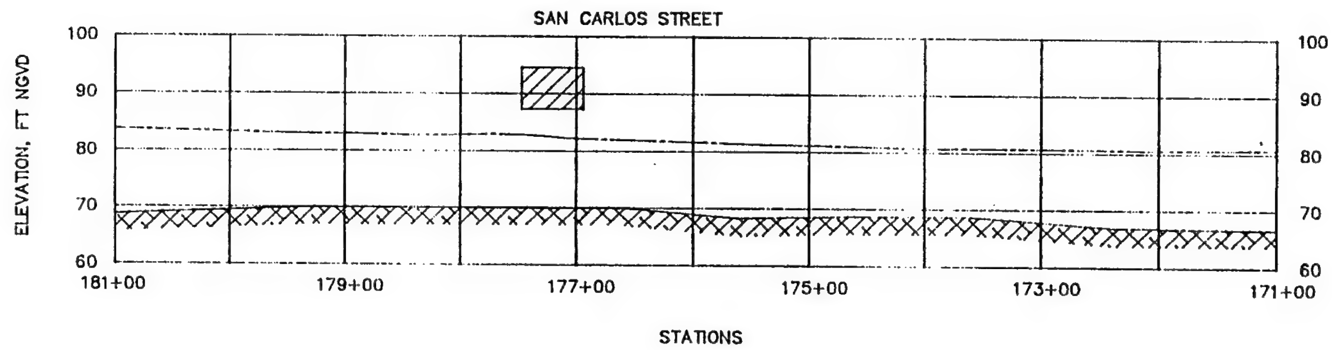
**WATER-SURFACE PROFILES**

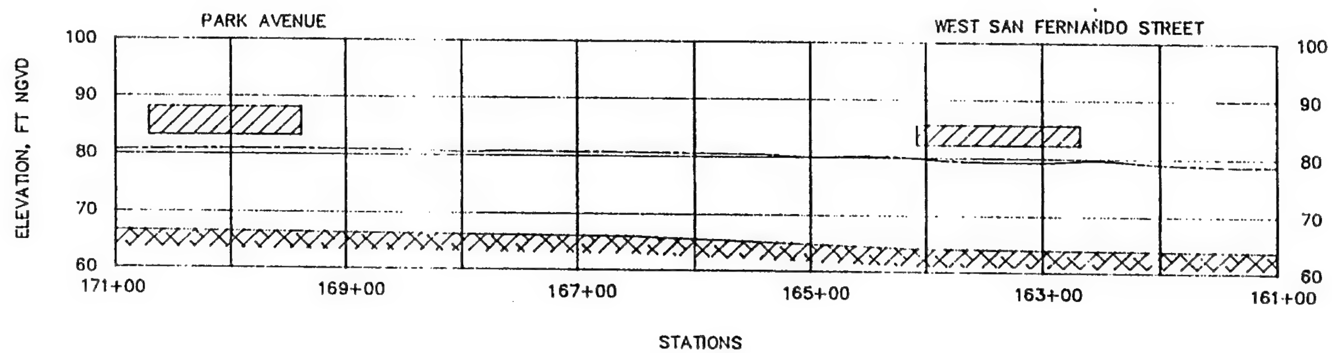
STA 203+00 TO STA 181+00

TYPE 2 DESIGN FUTURE CONDITIONS

DISCHARGE 14,600 CFS

WATER-SURFACE ELEVATION AT 151+27 = 77.6




LEGEND

------- CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)

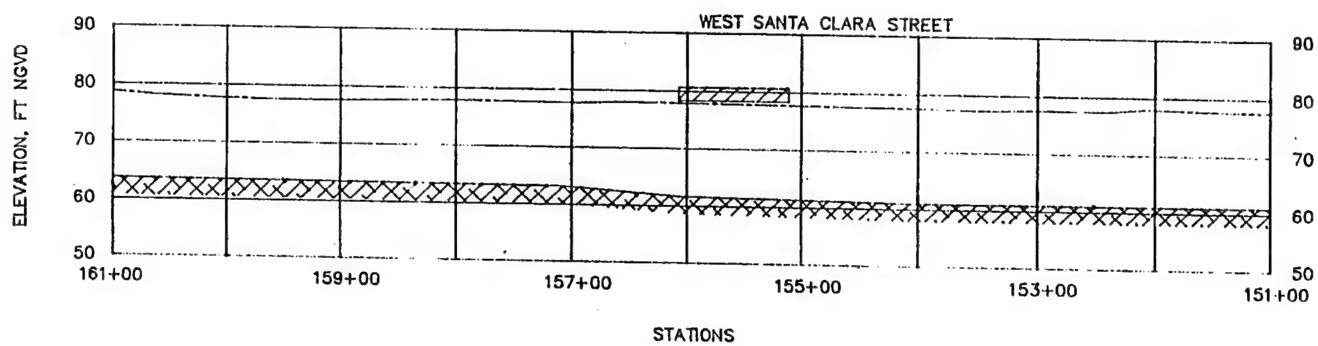
**WATER-SURFACE PROFILES**

STA 181+00 TO 161+00

TYPE 2 DESIGN FUTURE CONDITIONS

DISCHARGE 14,600 CFS

WATER-SURFACE ELEVATION AT STA 151+27 = 77.6




LEGEND

——·—— CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)

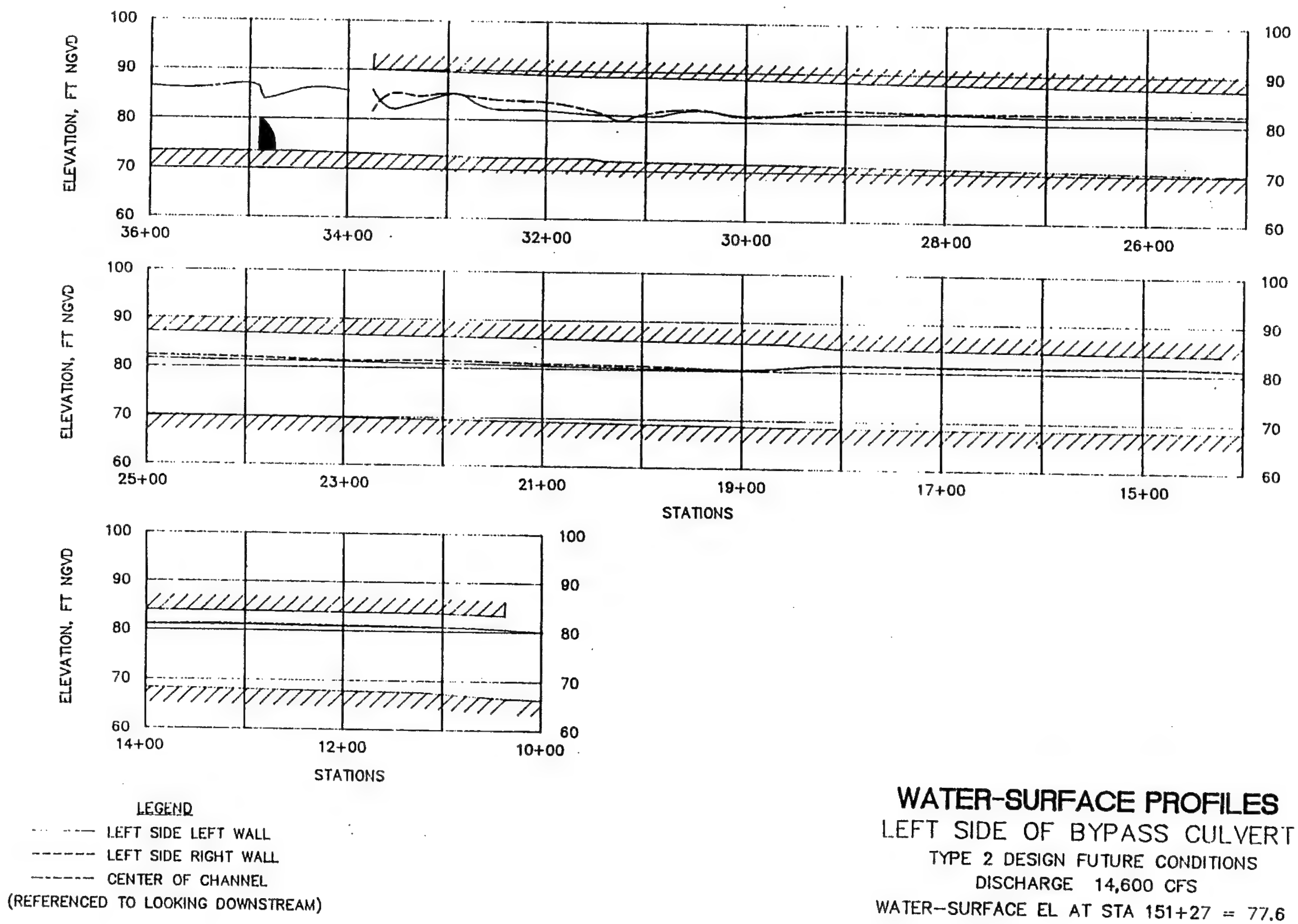
## WATER-SURFACE PROFILES

STA 161+00 TO STA 151+00

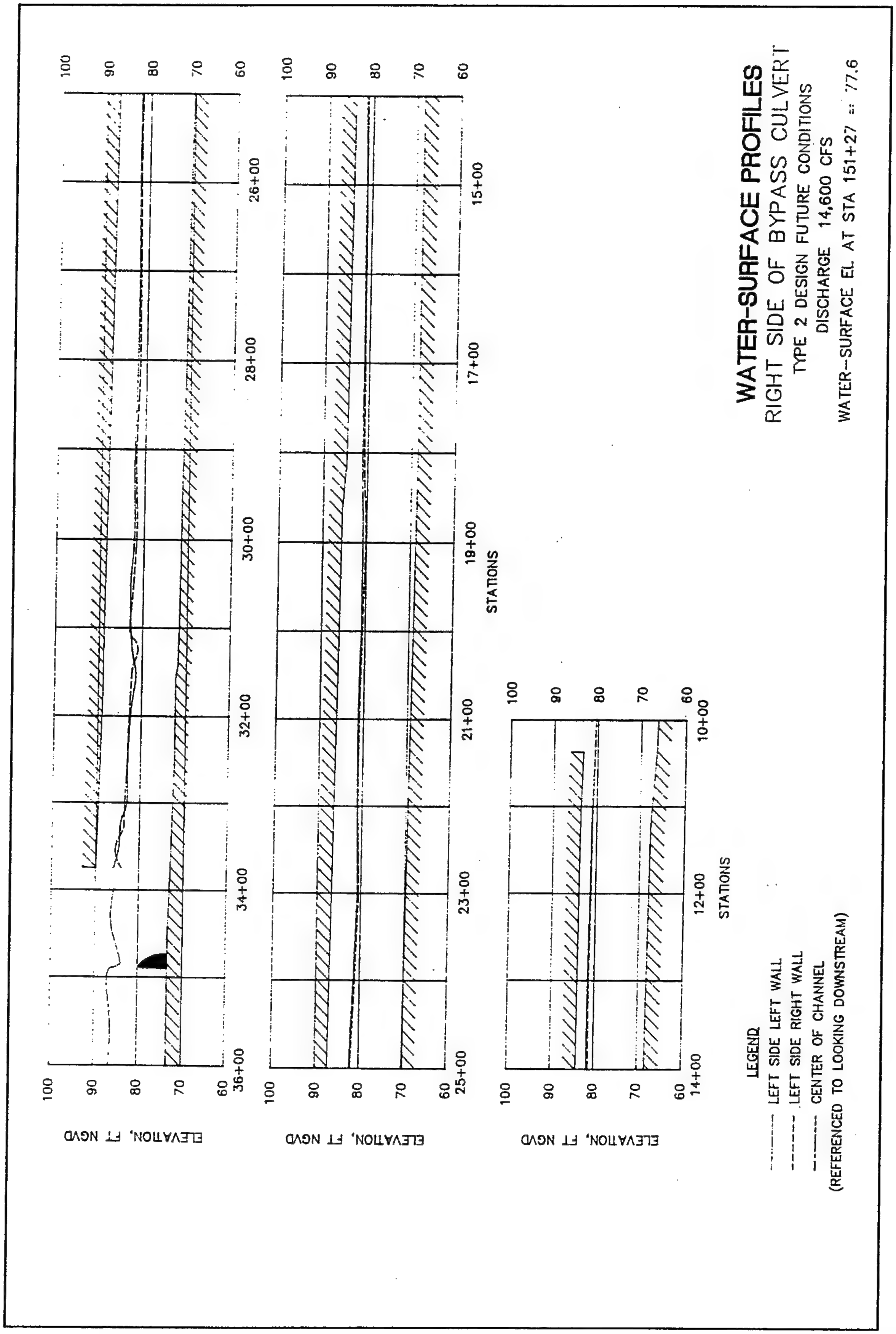
TYPE 2 FUTURE CONDITIONS

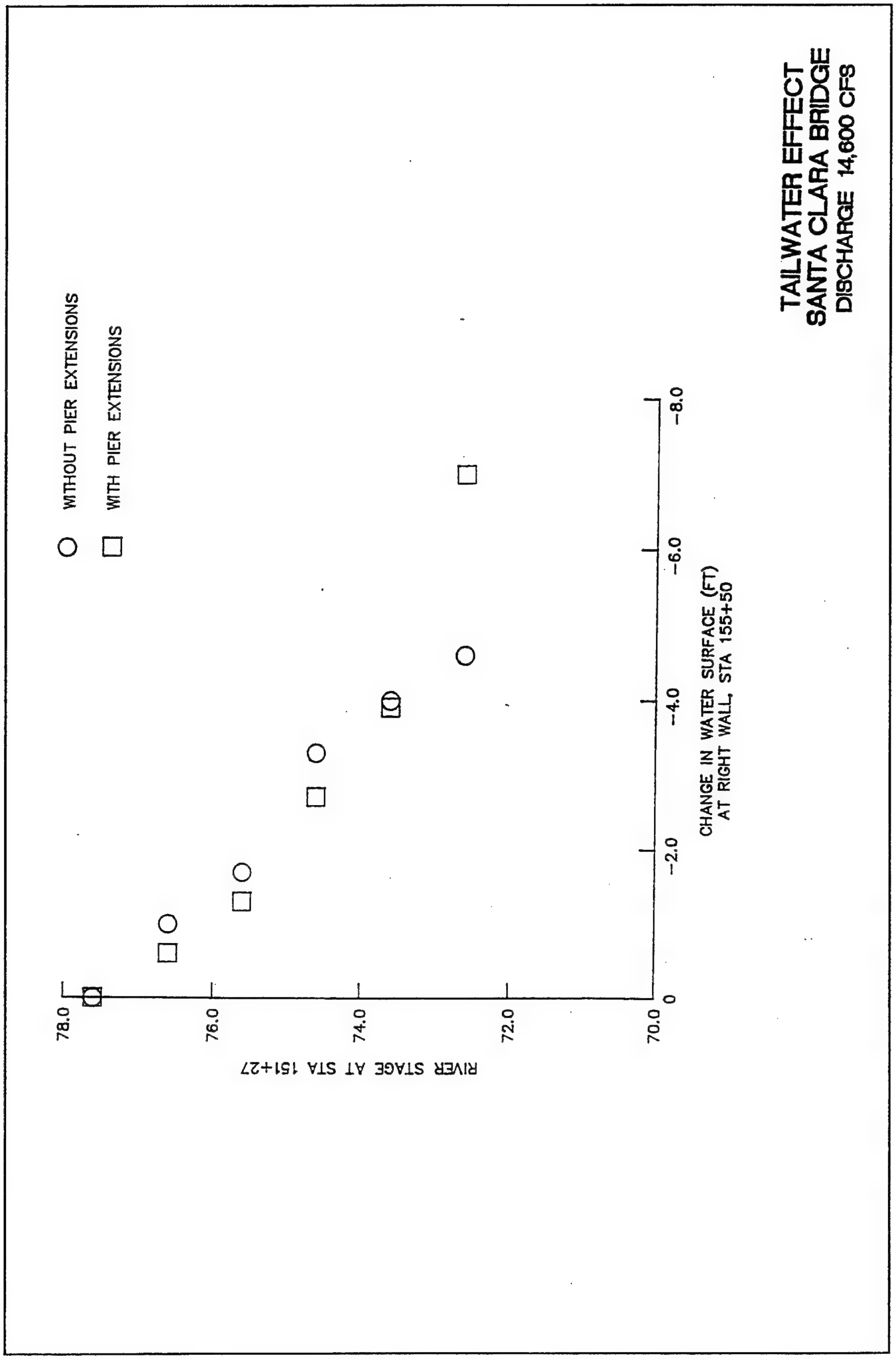
DISCHARGE 14,600 CFS

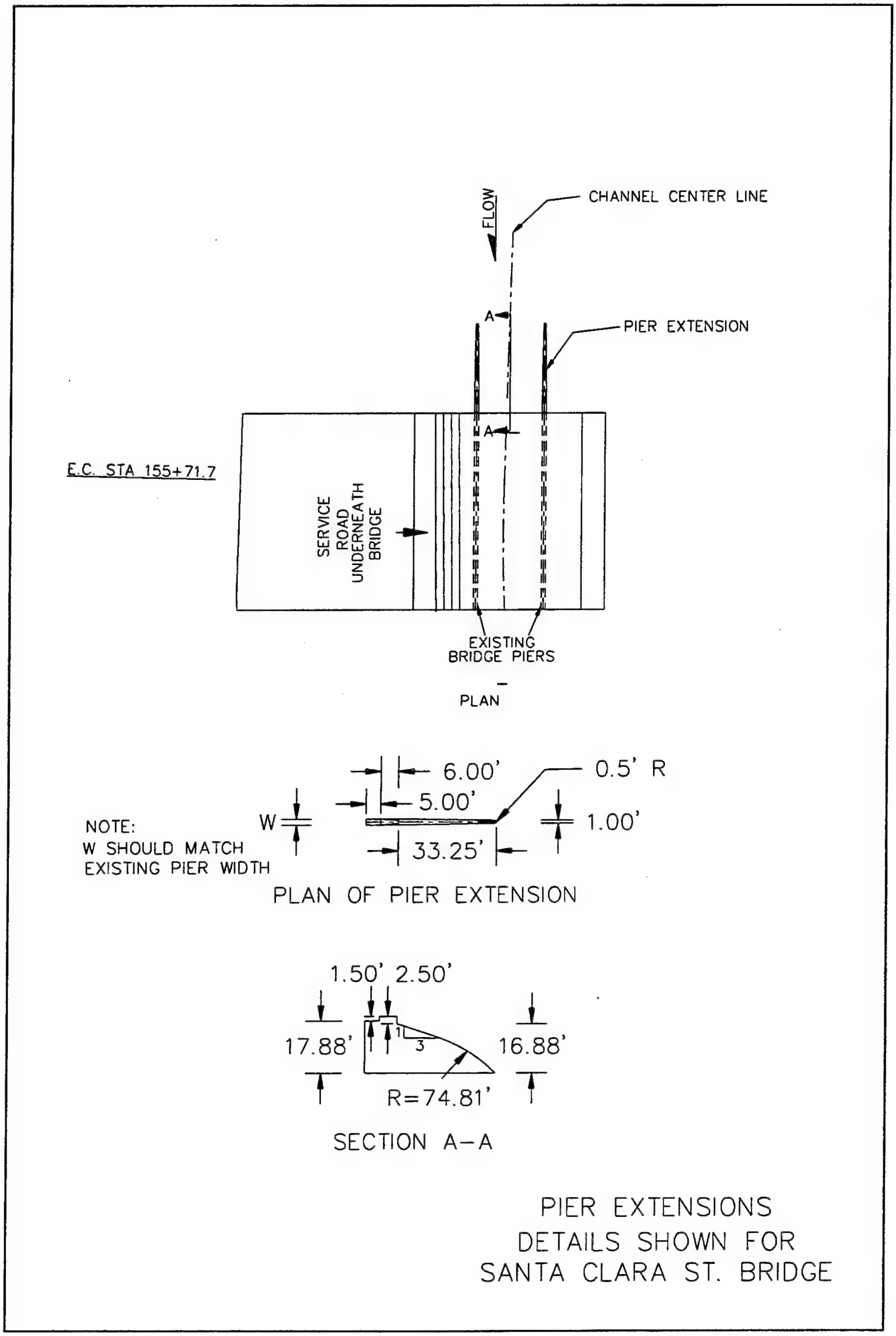
WATER-SURFACE ELEVATION AT STA 151+27 = 77.6



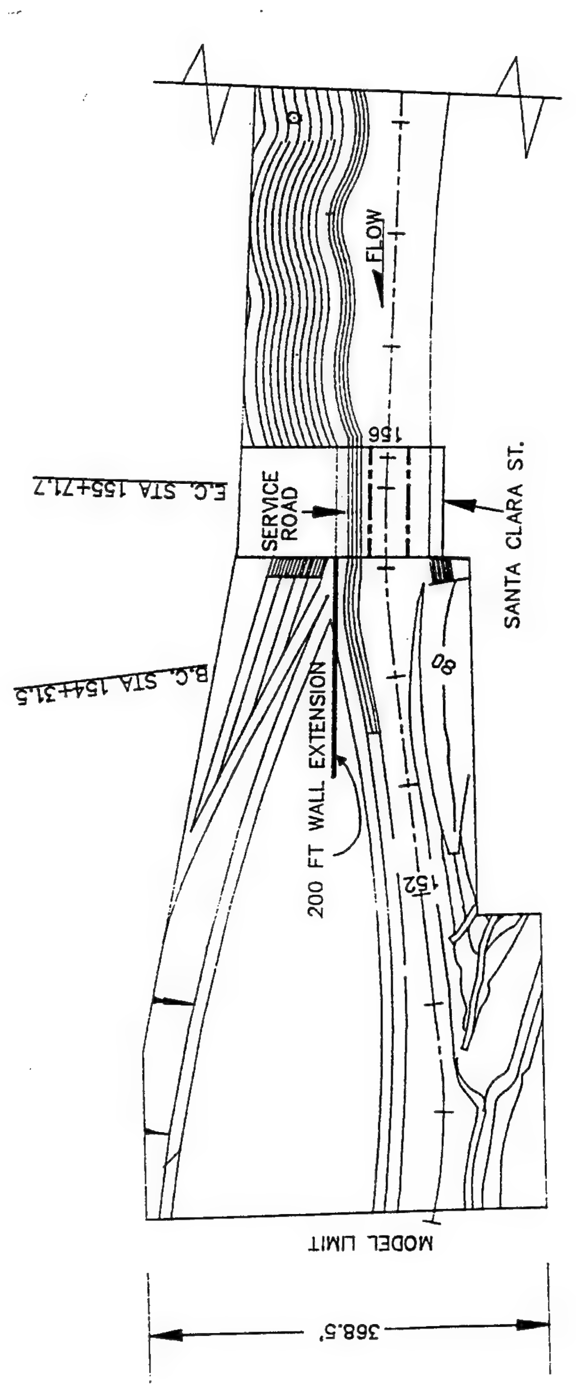

**WATER-SURFACE PROFILES**
LEFT SIDE OF BYPASS CULVERT
TYPE 2 DESIGN FUTURE CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE EL AT STA 151+27 = 77.6


WATER-SURFACE PROFILES
RIGHT SIDE OF BYPASS CULVERT
TYPE 2 DESIGN FUTURE CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE EL AT STA 151+27 = 77.6
LEGEND
LEFT SIDE LEFT WALL
LEFT SIDE RIGHT WALL
CENTER OF CHANNEL
(REFERENCED TO LOOKING DOWNSTREAM)
ELEVATION, FT NGVD
STATIONS
100
90
80
70
60
36+00
34+00
32+00
30+00
28+00
26+00
25+00
23+00
21+00
19+00
17+00
15+00
14+00
12+00
10+00

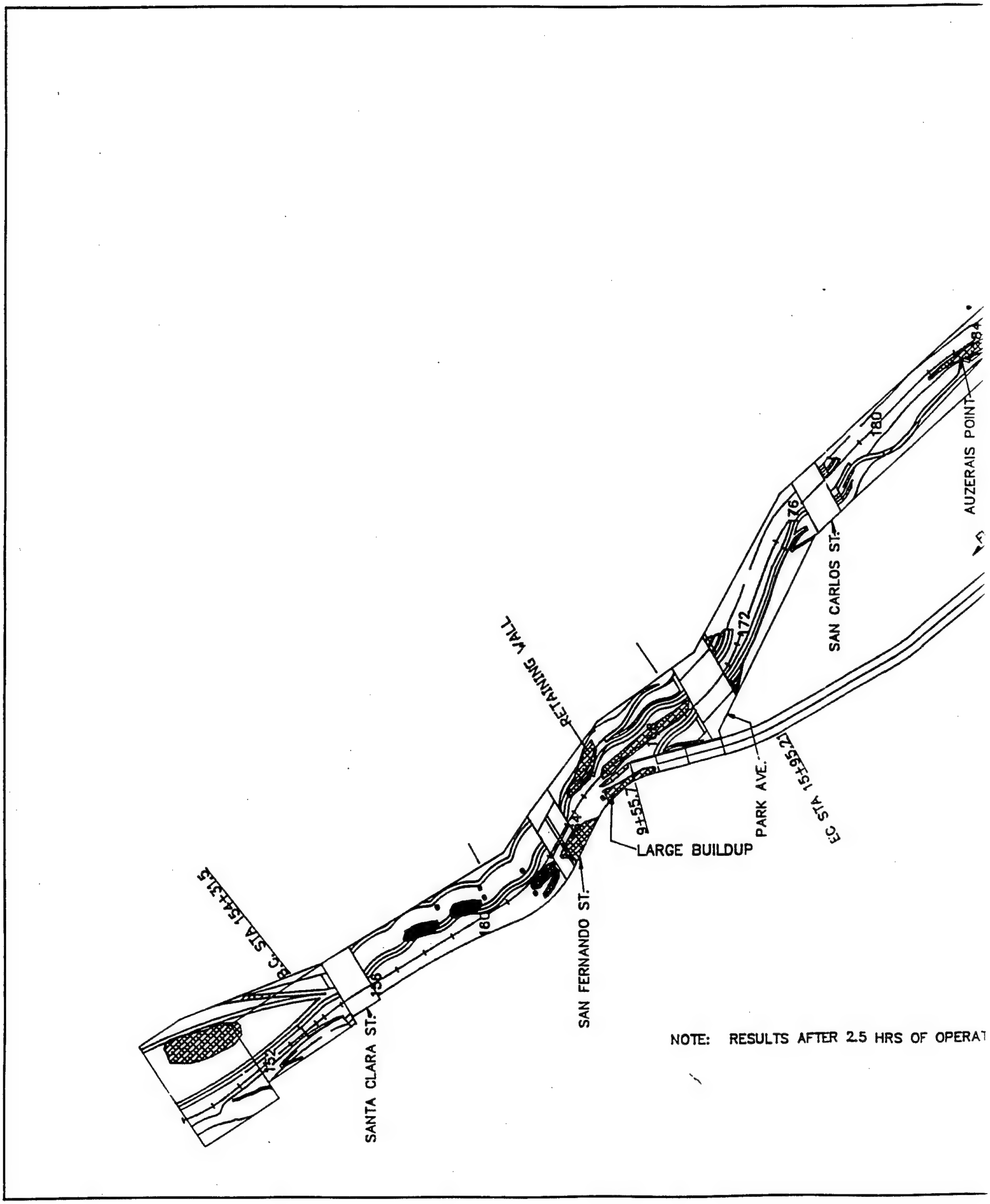

TAILWATER EFFECT
SANTA CLARA BRIDGE
DISCHARGE 14,600 CFS
WITHOUT PIER EXTENSIONS
WITH PIER EXTENSIONS
RIVER STAGE AT STA 151+27
CHANGE IN WATER SURFACE (FT)
AT RIGHT WALL, STA 155+50
78.0
76.0
74.0
72.0
70.0
0
-2.0
-4.0
-6.0
-8.0



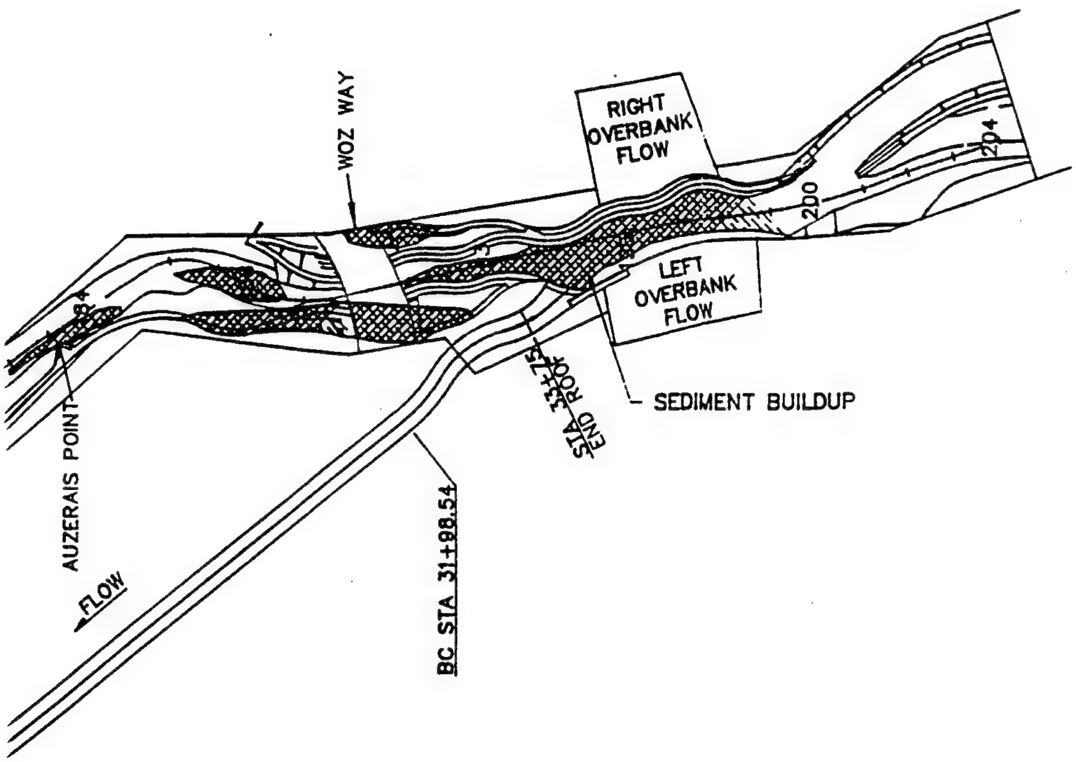
FLOW
CHANNEL CENTER LINE
A
PIER EXTENSION
A
E.C. STA 155+71.7
SERVICE ROAD UNDERNEATH BRIDGE
EXISTING BRIDGE PIERS
PLAN
6.00'
0.5' R
5.00'
W
1.00'
NOTE:
W SHOULD MATCH
EXISTING PIER WIDTH
33.25'
PLAN OF PIER EXTENSION
1.50' 2.50'
1
3
17.88'
16.88'
R=74.81'
SECTION A-A
PIER EXTENSIONS
DETAILS SHOWN FOR
SANTA CLARA ST. BRIDGE




SANTA CLARA ST. BRIDGE
WALL EXTENSION

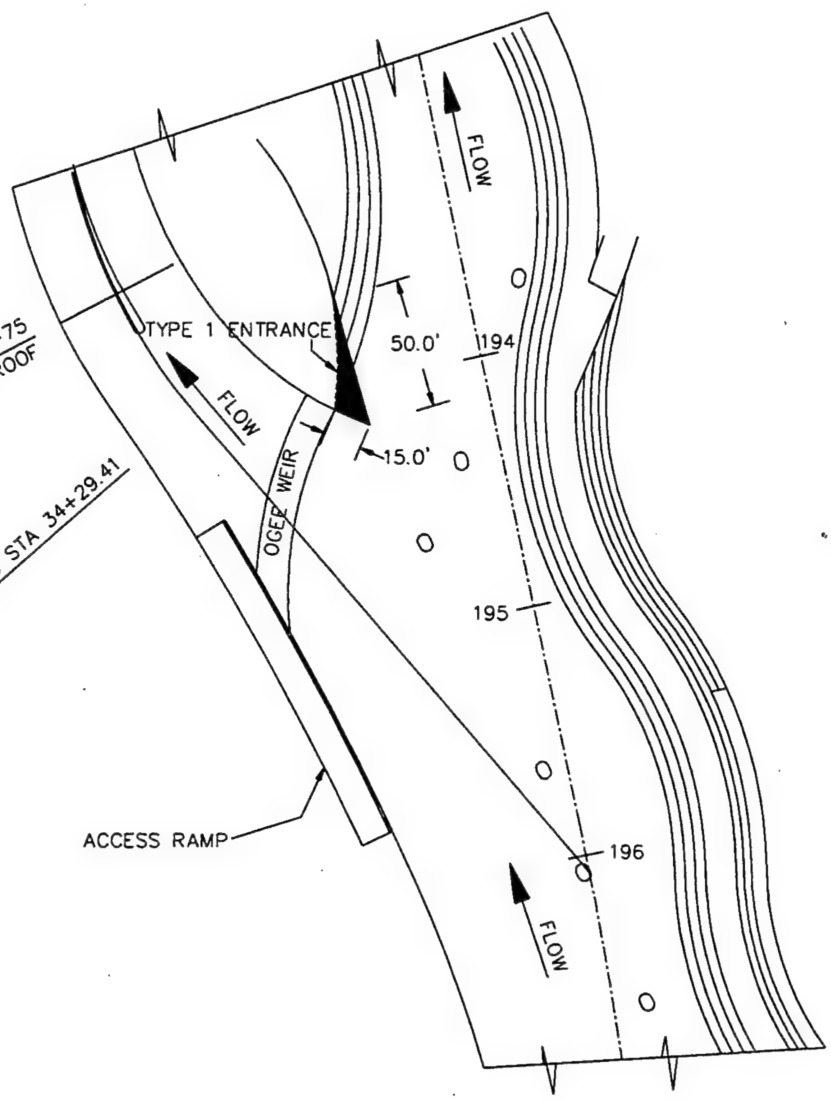

B.C. STA 154+31.5
SANTA CLARA ST.
156
160
SAN FERNANDO ST.
RETAINING WALL
9+55.7
LARGE BUILDUP
PARK AVE.
EC STA 15+95.22
172
176
SAN CARLOS ST.
180
AUZERAIS POINT
NOTE: RESULTS AFTER 2.5 HRS OF OPERAT

1

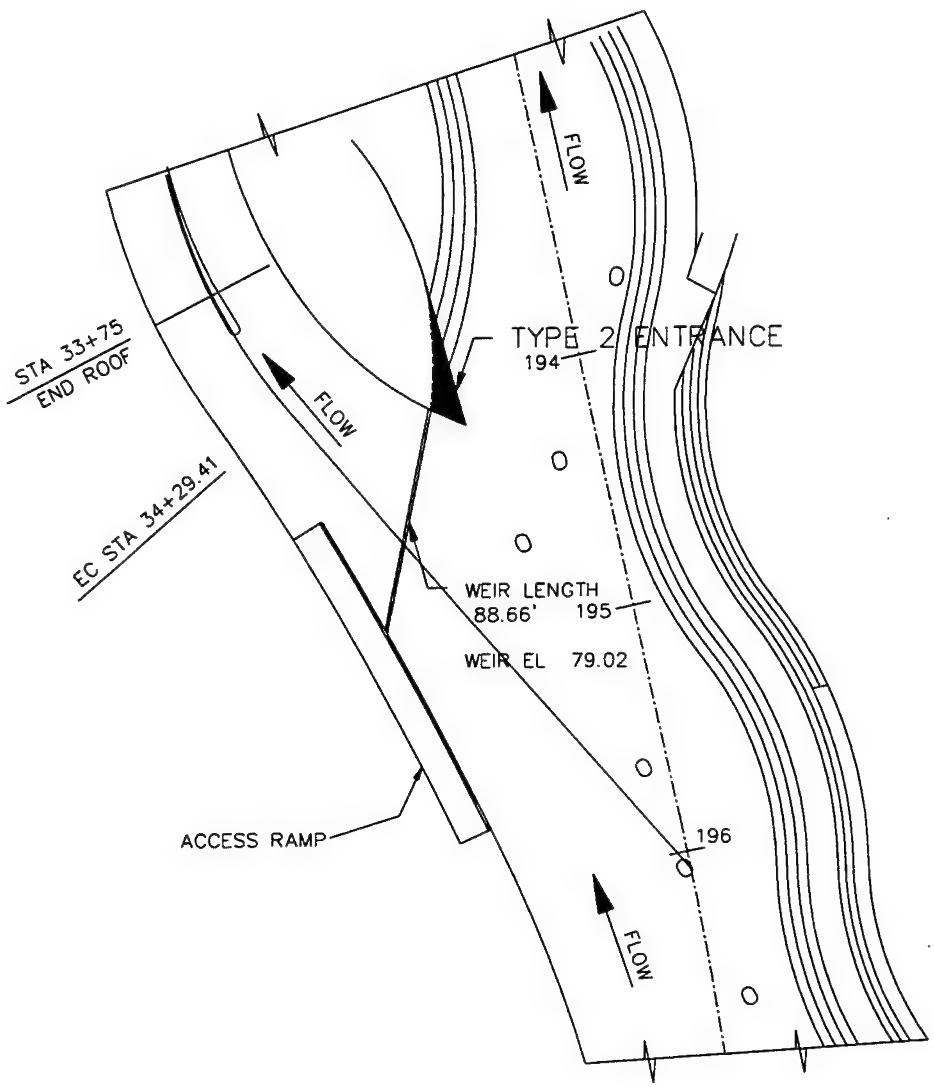



OPERATON WITH A DISCHARGE OF 14,600 CFS

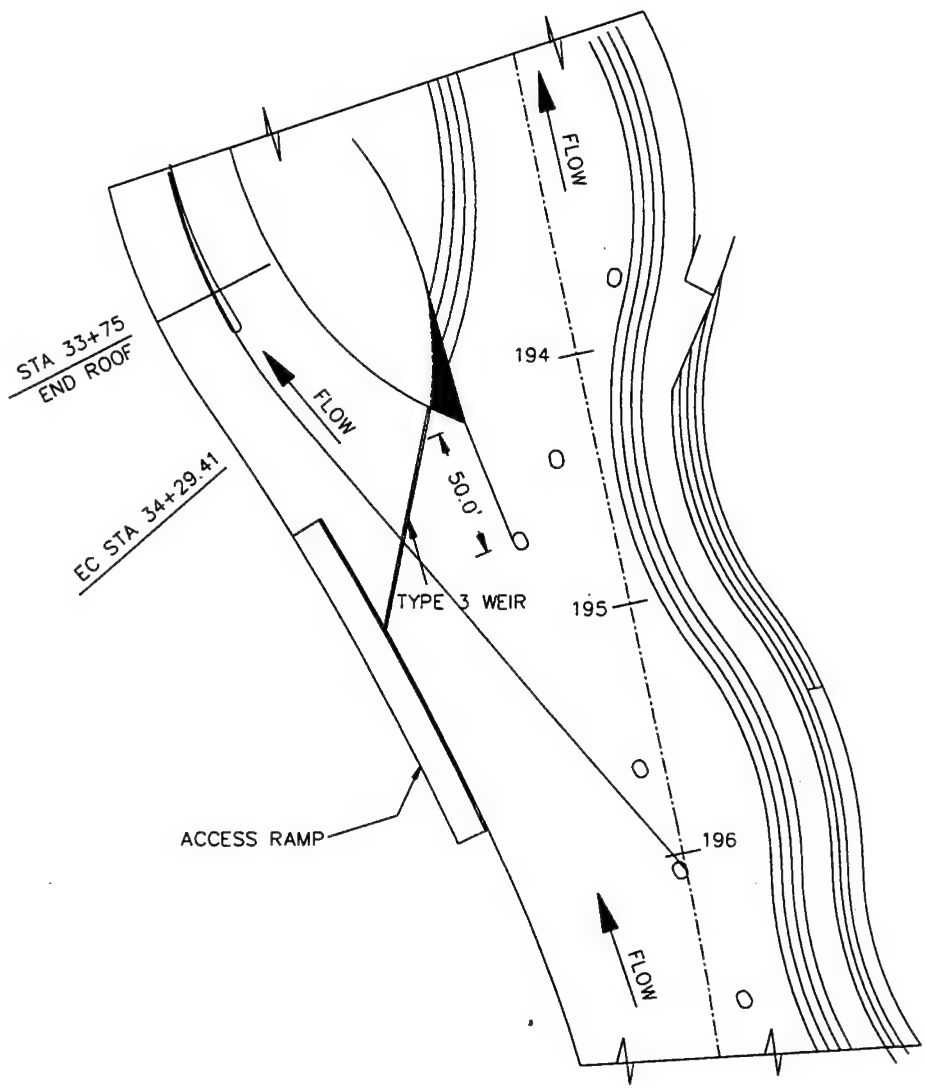
SEDIMENT DEPOSITS



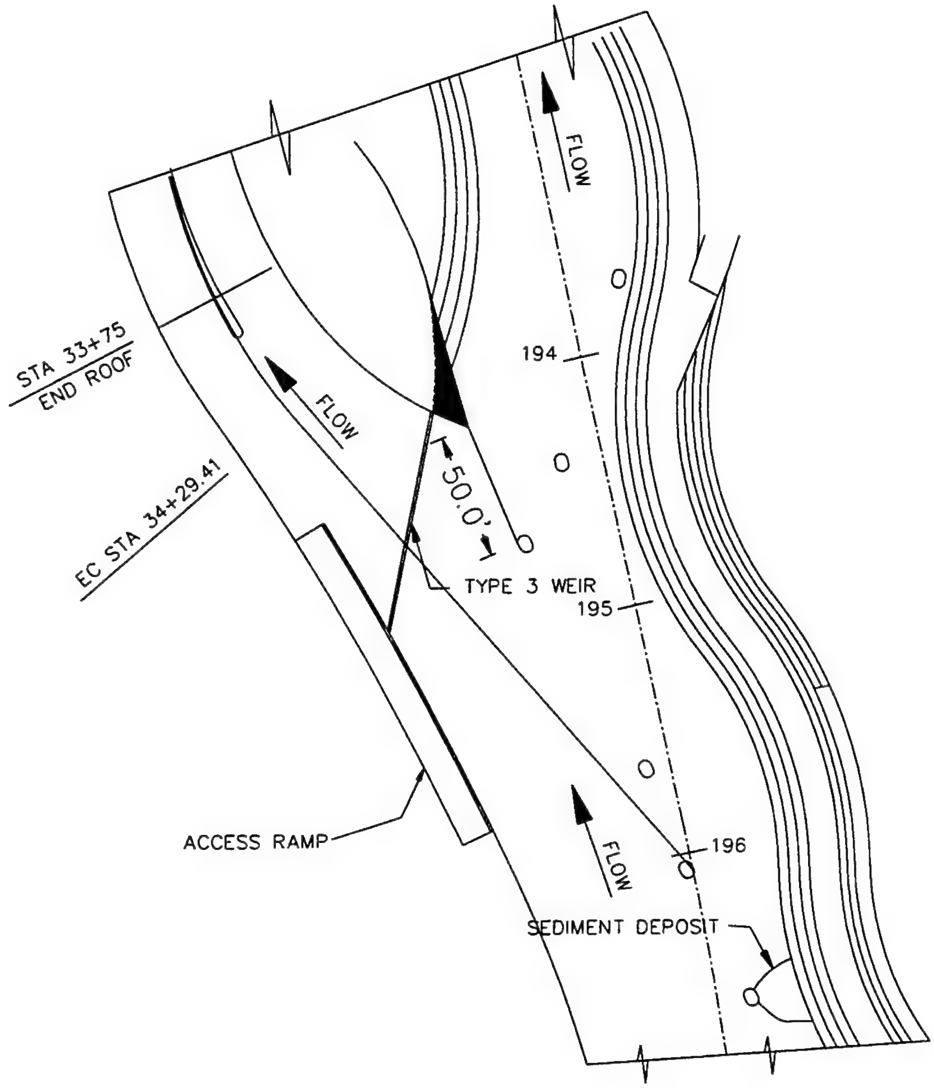

TYPE 2 BYPASS ENTRANCE



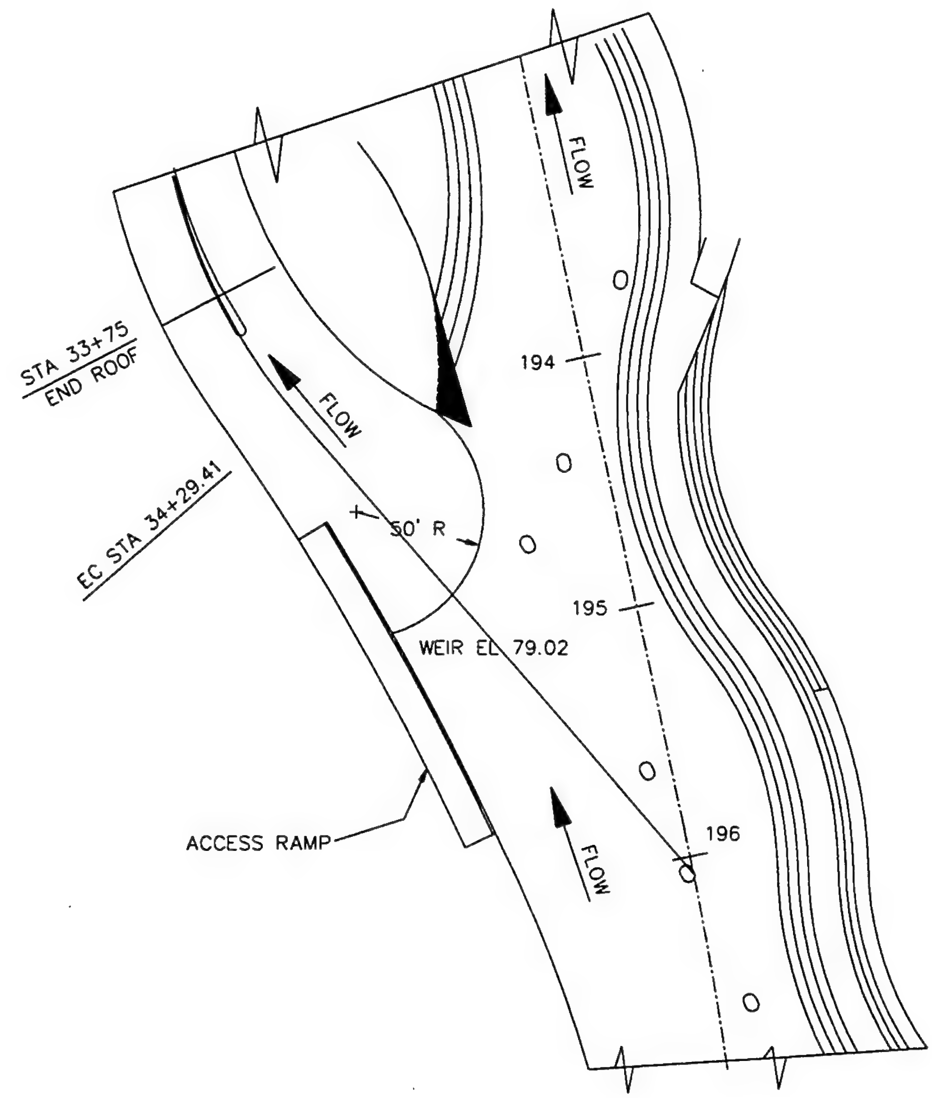

TYPE 3 DESIGN WEIR
TYPE 2 BYPASS ENTRANCE



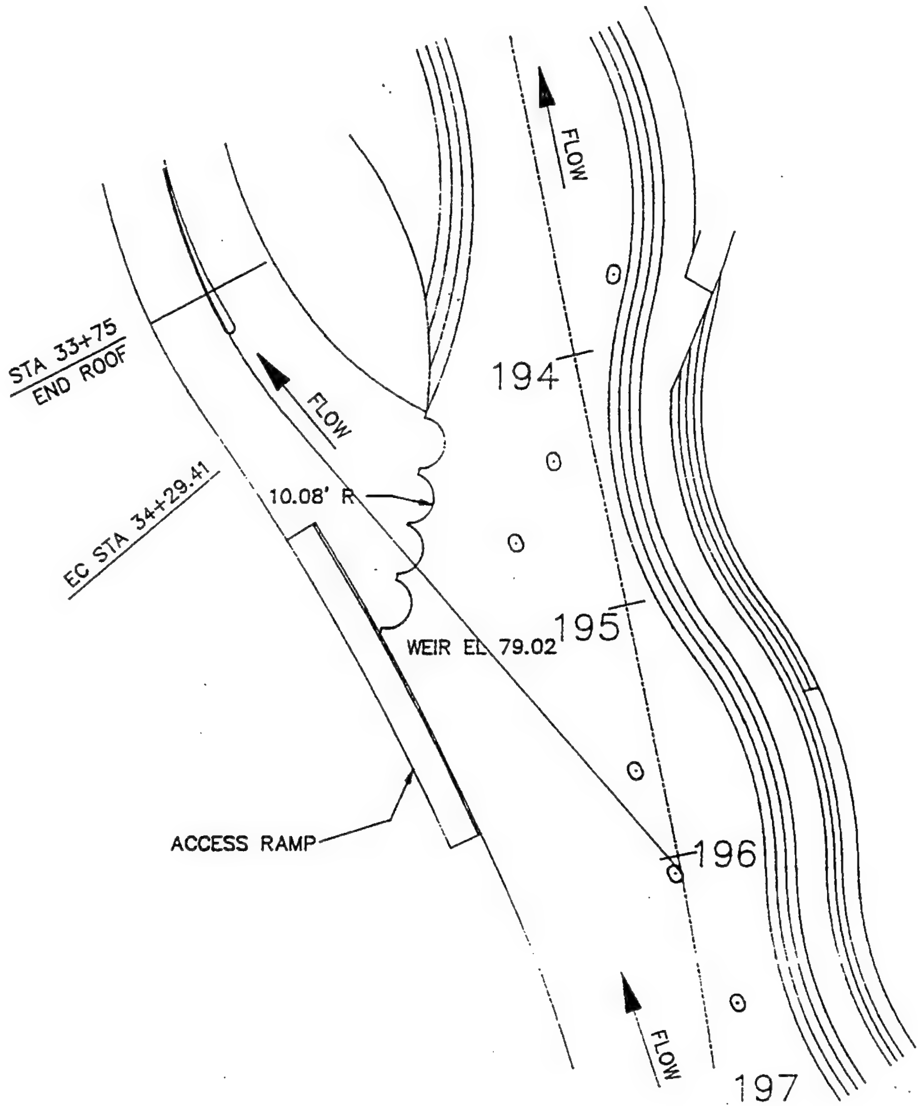

TYPE 3 BYPASS ENTRANCE
TYPE 3 DESIGN WEIR



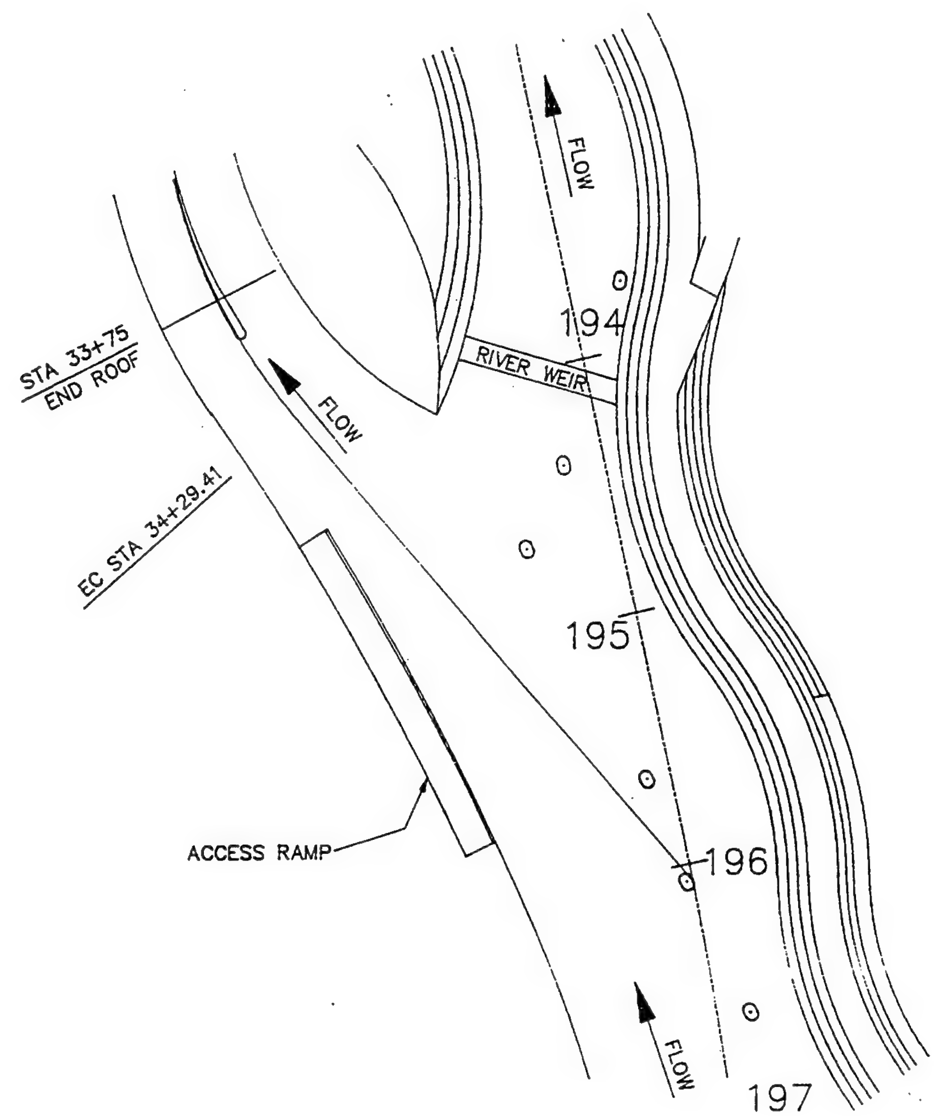

TYPE 3 UPSTREAM CHANNEL
TYPE 3 BYPASS ENTRANCE
TYPE 3 DESIGN WEIR



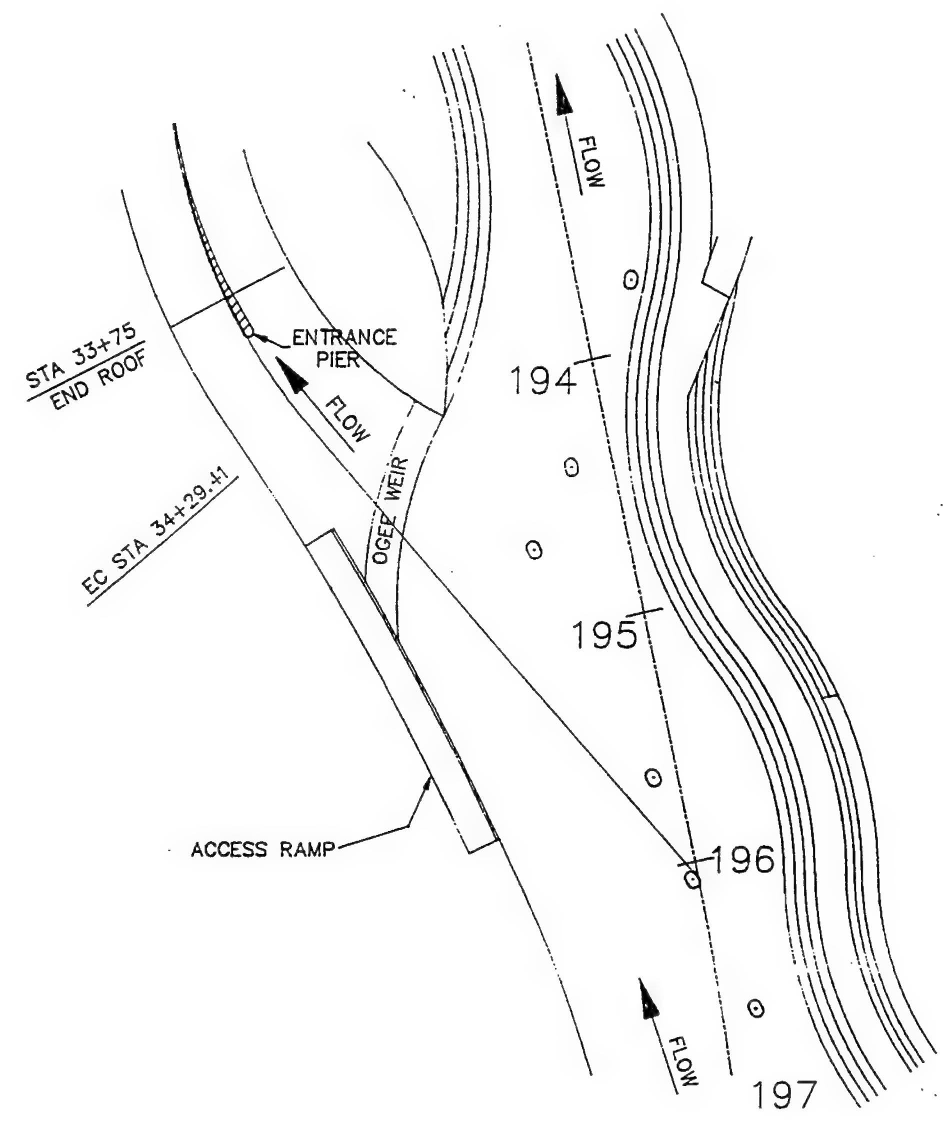

TYPE 4 DESIGN WEIR
TYPE 2 BYPASS ENTRANCE



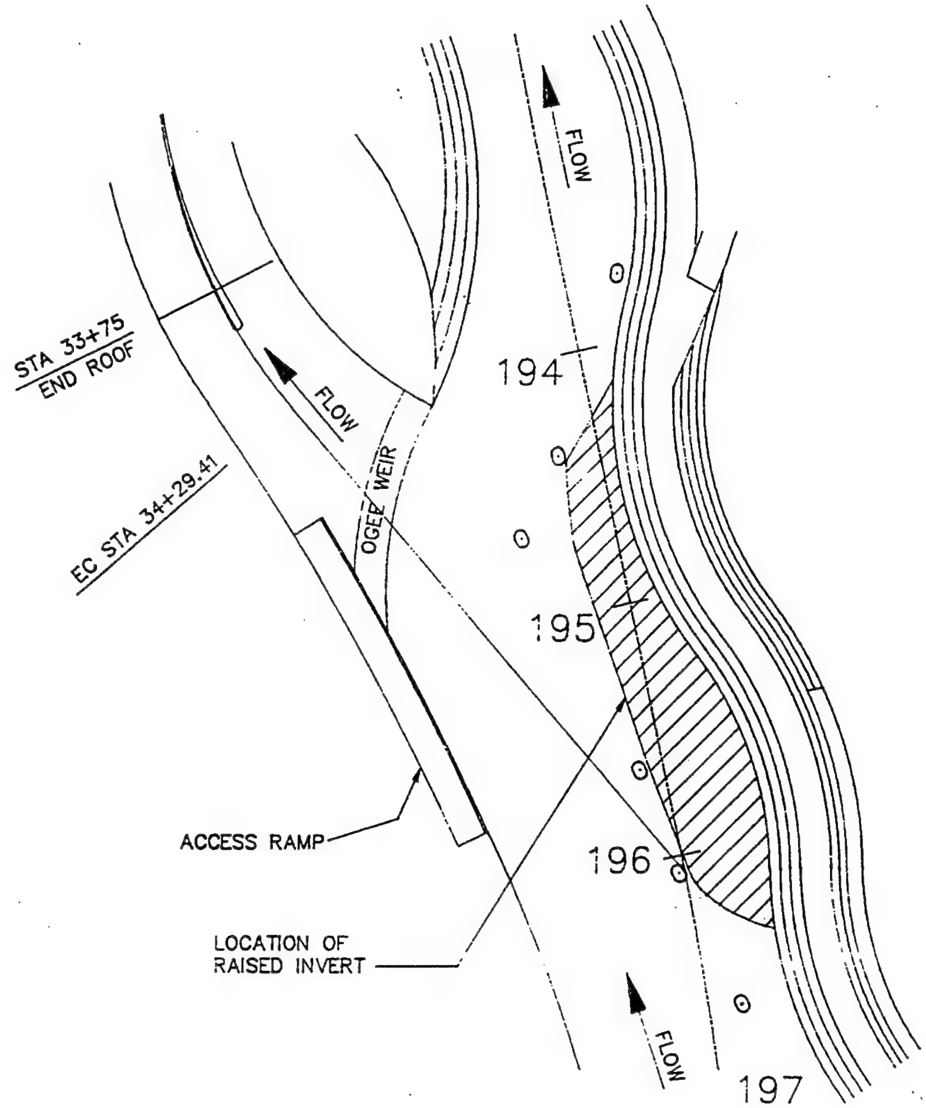

TYPE 5 DESIGN WEIR




RIVER WEIR LOCATION




ENTRANCE PIER LOCATION

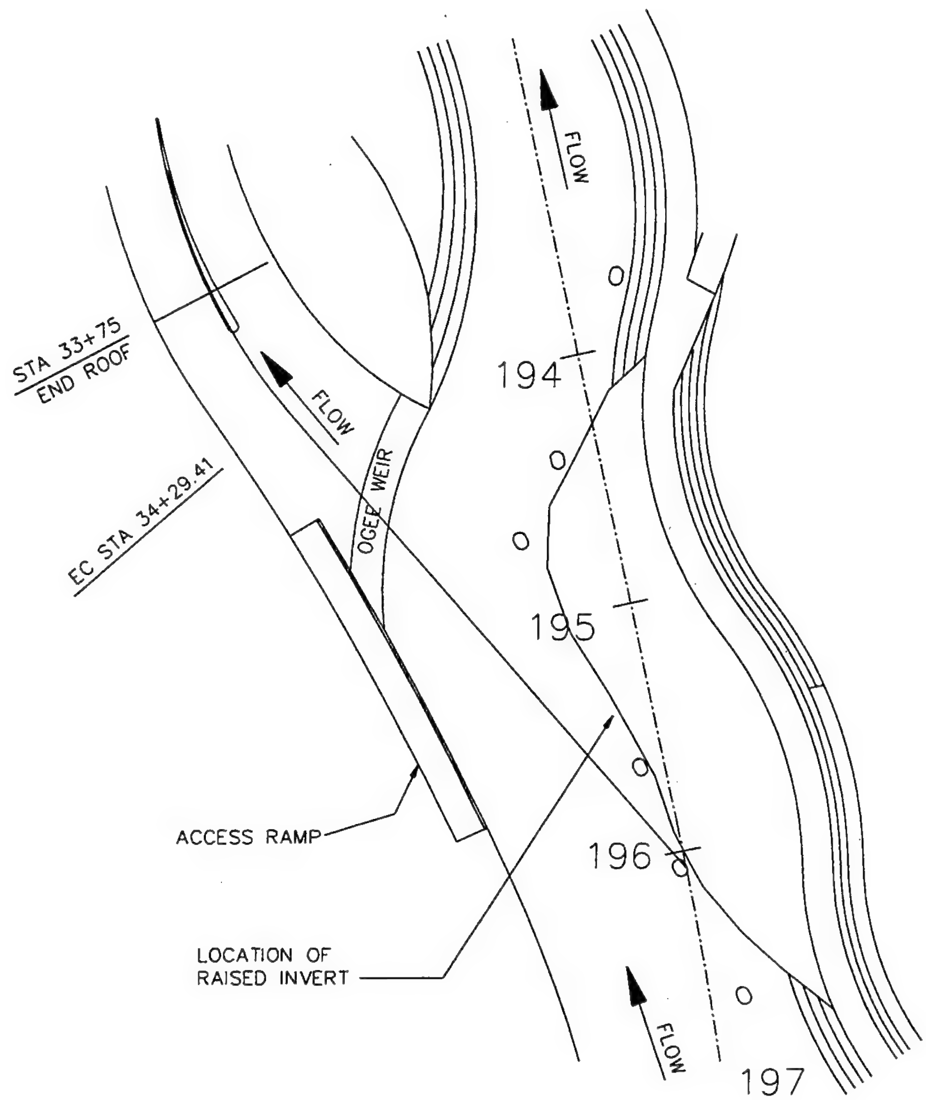



NOTE: TYPE 4 UPSTREAM CHANNEL INVERT RAISED 4.75'

TYPE 5 UPSTREAM CHANNEL INVERT RAISED 9.5'

TYPE 6 UPSTREAM CHANNEL INVERT RAISED 9.5' AND CONSTRUCTED OF GROUTED PEA GRAVEL

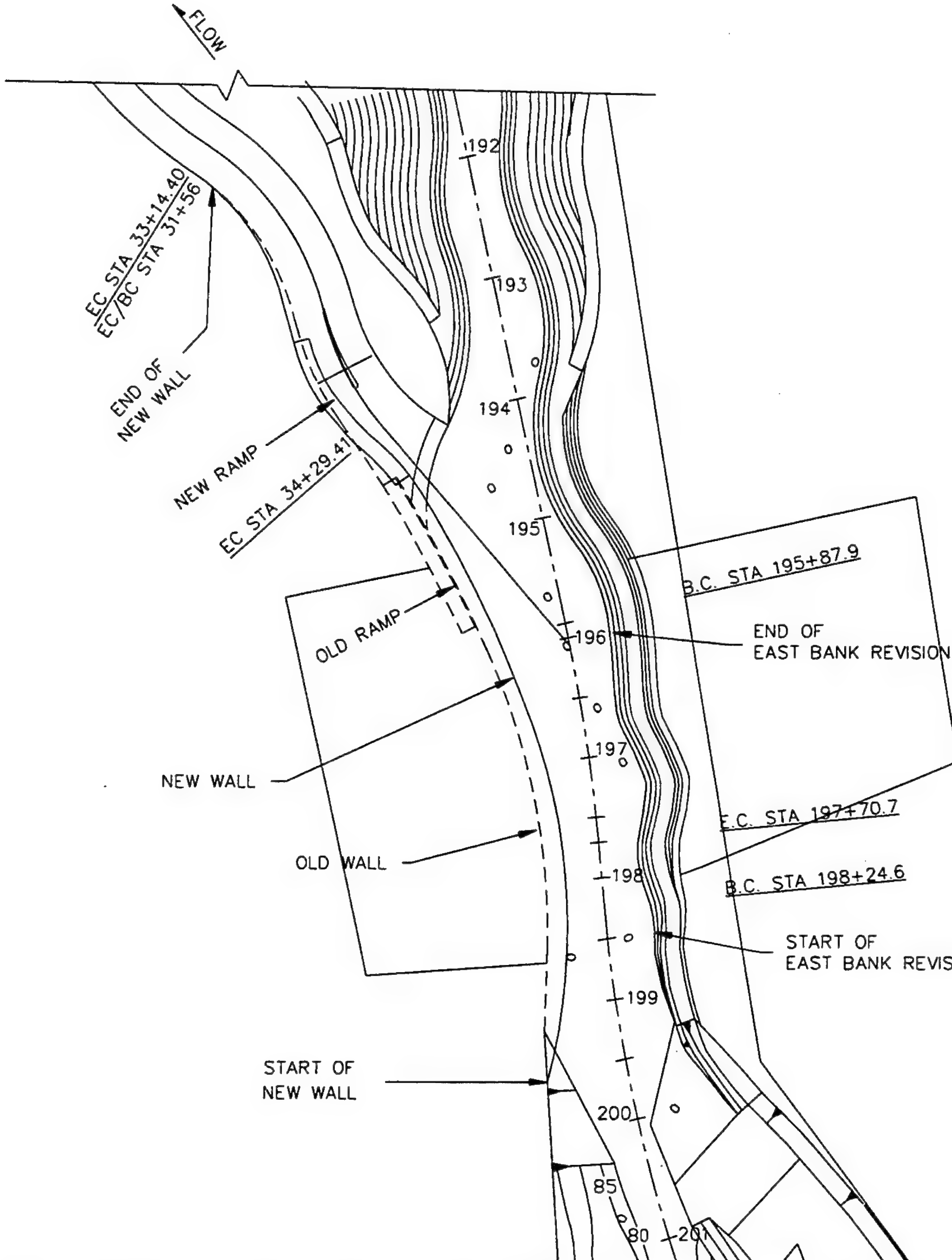
**TYPES 4,5 AND 6 UPSTREAM CHANNEL**




NOTE: TYPE 7 UPSTREAM CHANNEL INVERT RAISED 9.5'
TYPE 8 UPSTREAM CHANNEL INVERT RAISED 12.5'

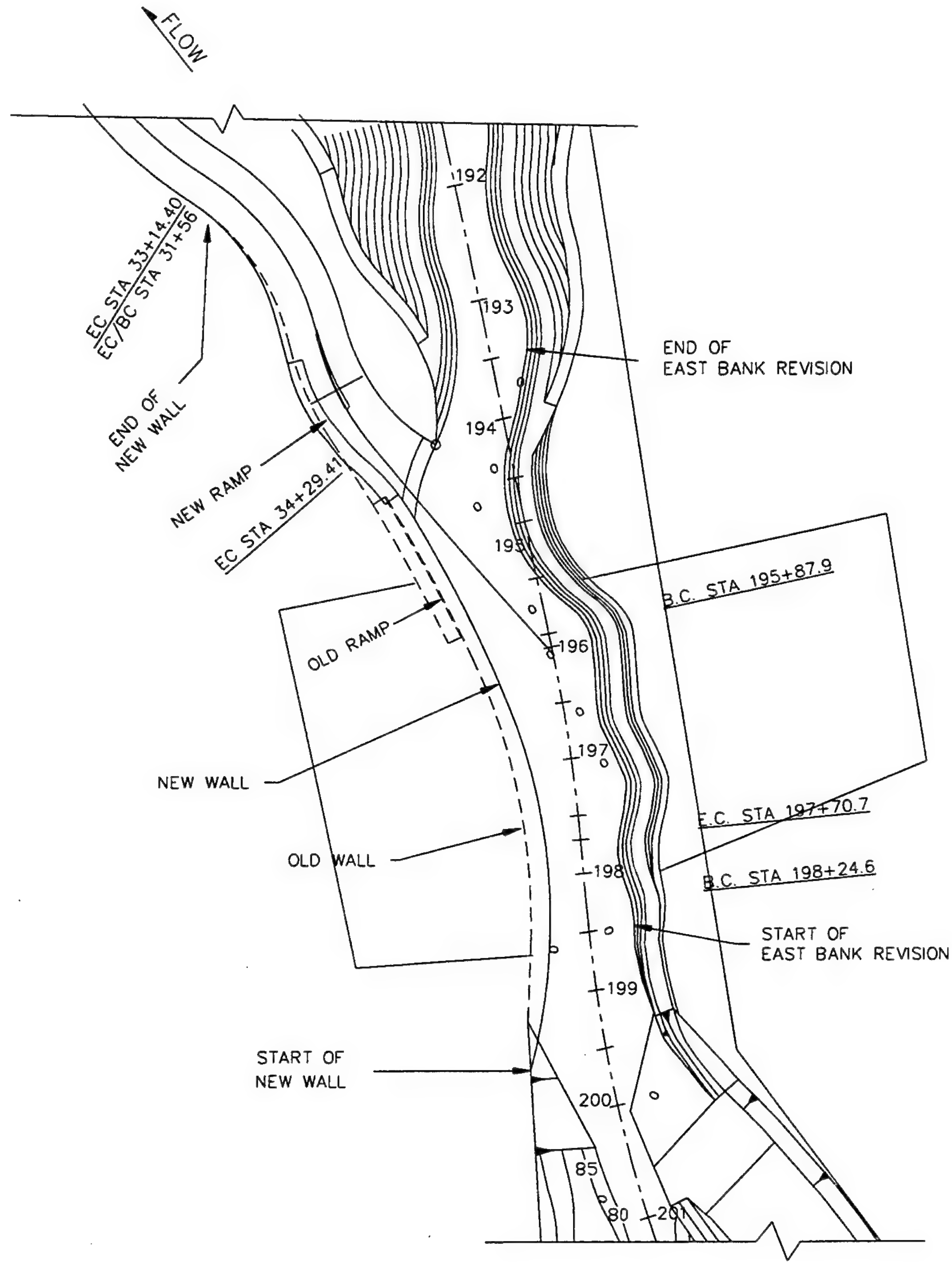
TYPES 7 AND 8 UPSTREAM CHANNEL

Plate 36

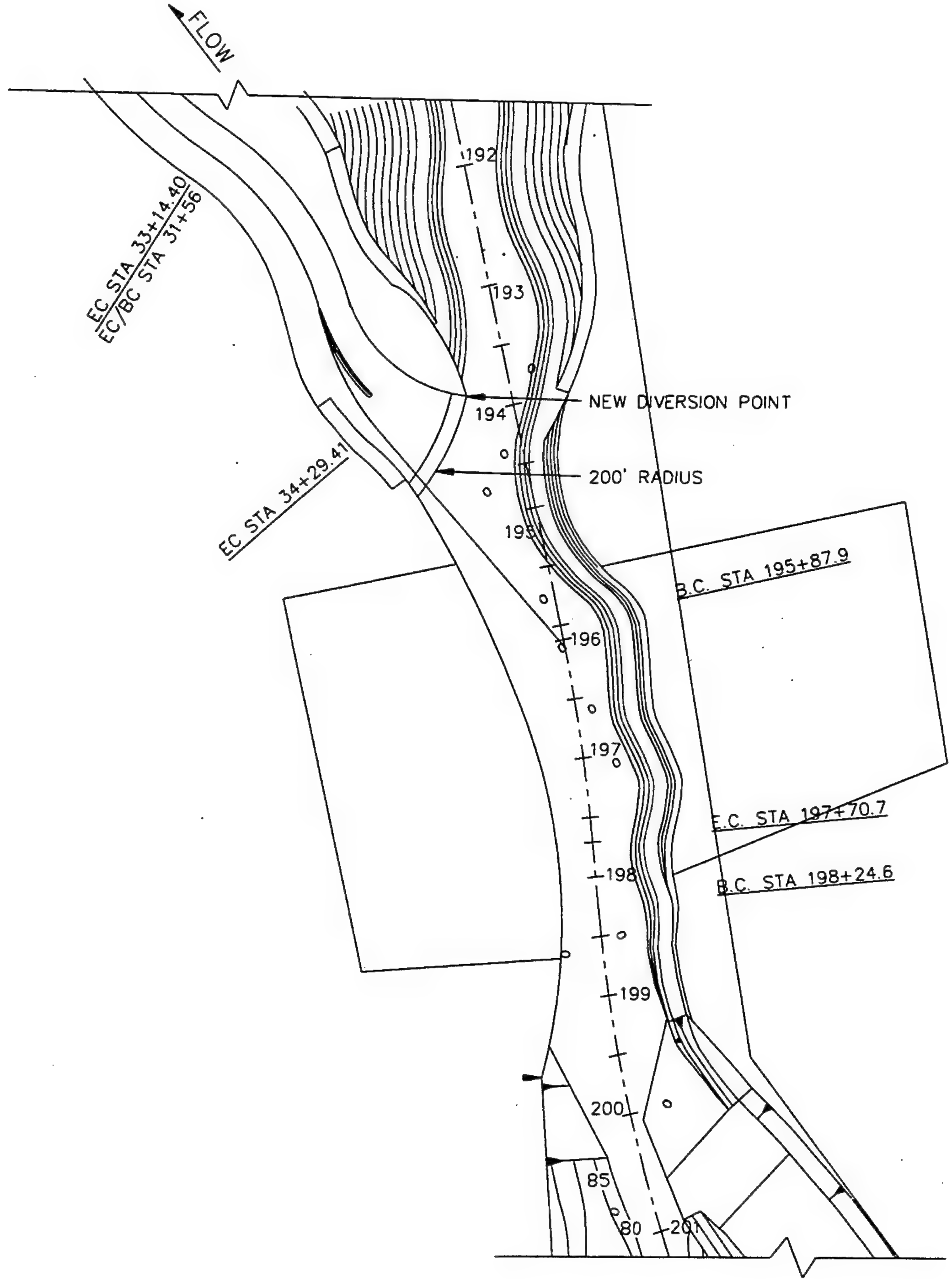



NOTE: TYPE 9 UPSTREAM CHANNEL CONSISTS OF NEW LEFT WALL
TYPE 10 UPSTREAM CHANNEL CONSISTS OF MODIFICATIONS TO BOTH BANKS

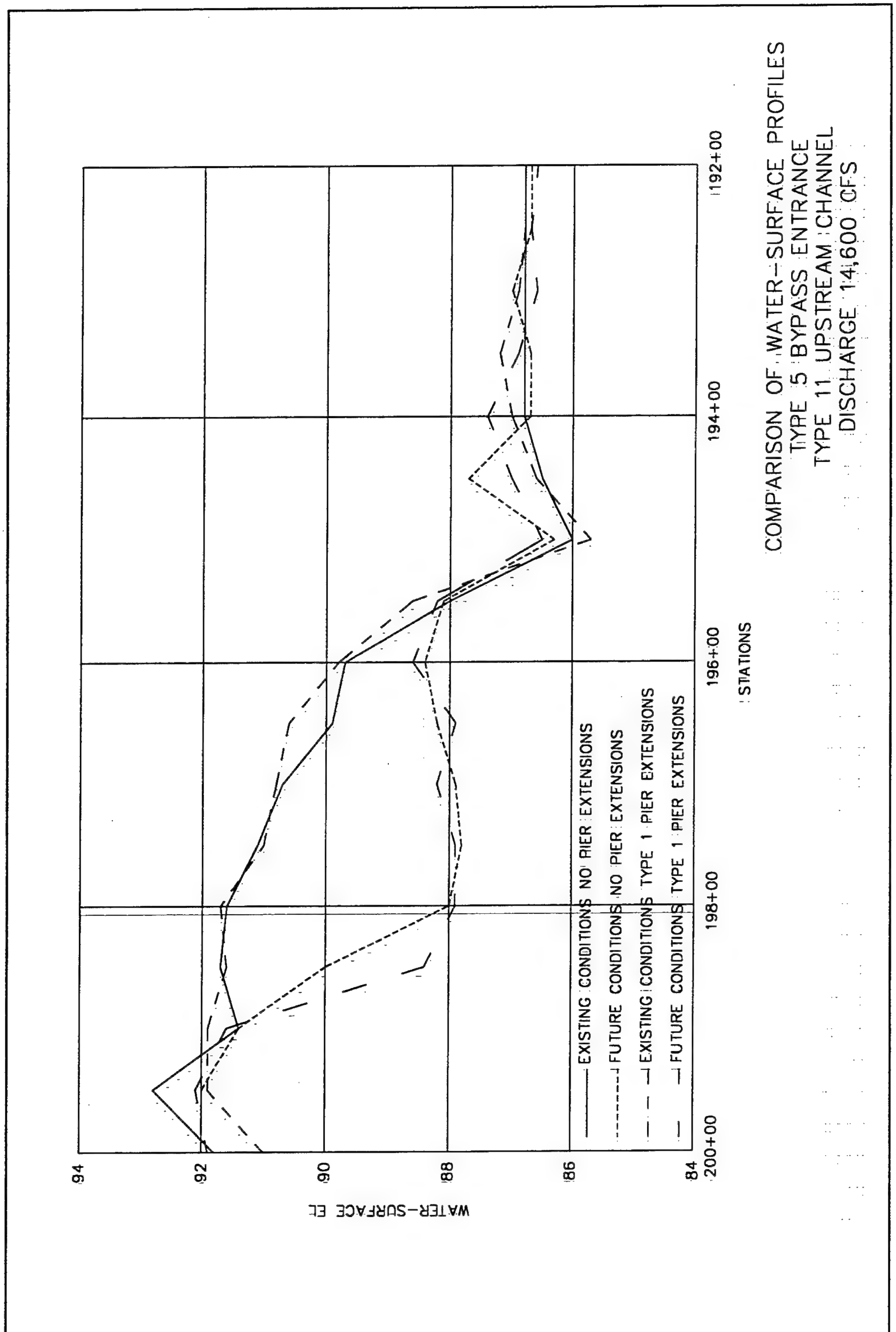
TYPE 4 BYPASS ENTRANCE
TYPES 9 AND 10 UPSTREAM CHANNEL

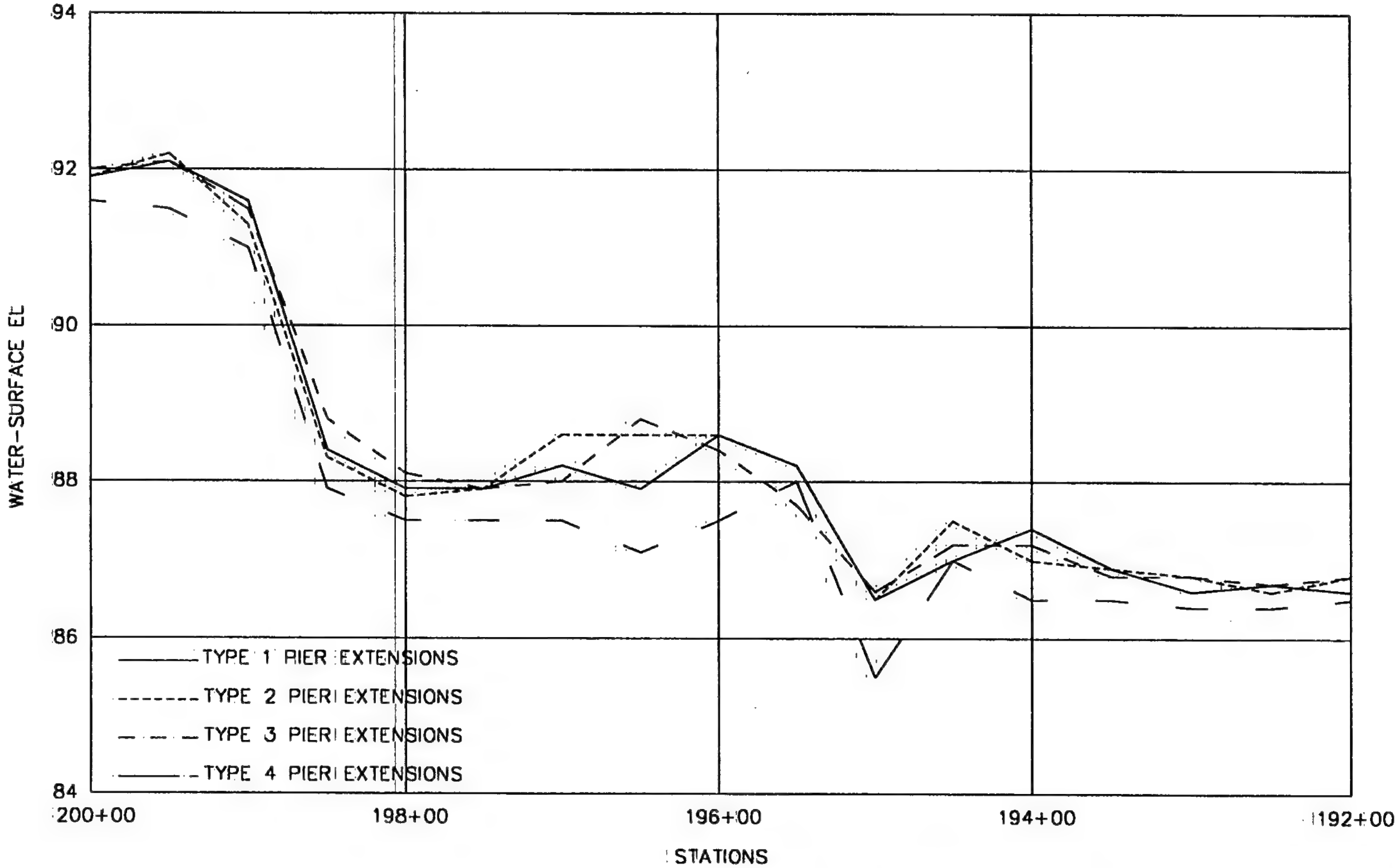



TYPE 4 BYPASS ENTRANCE
TYPE 11 UPSTREAM CHANNEL

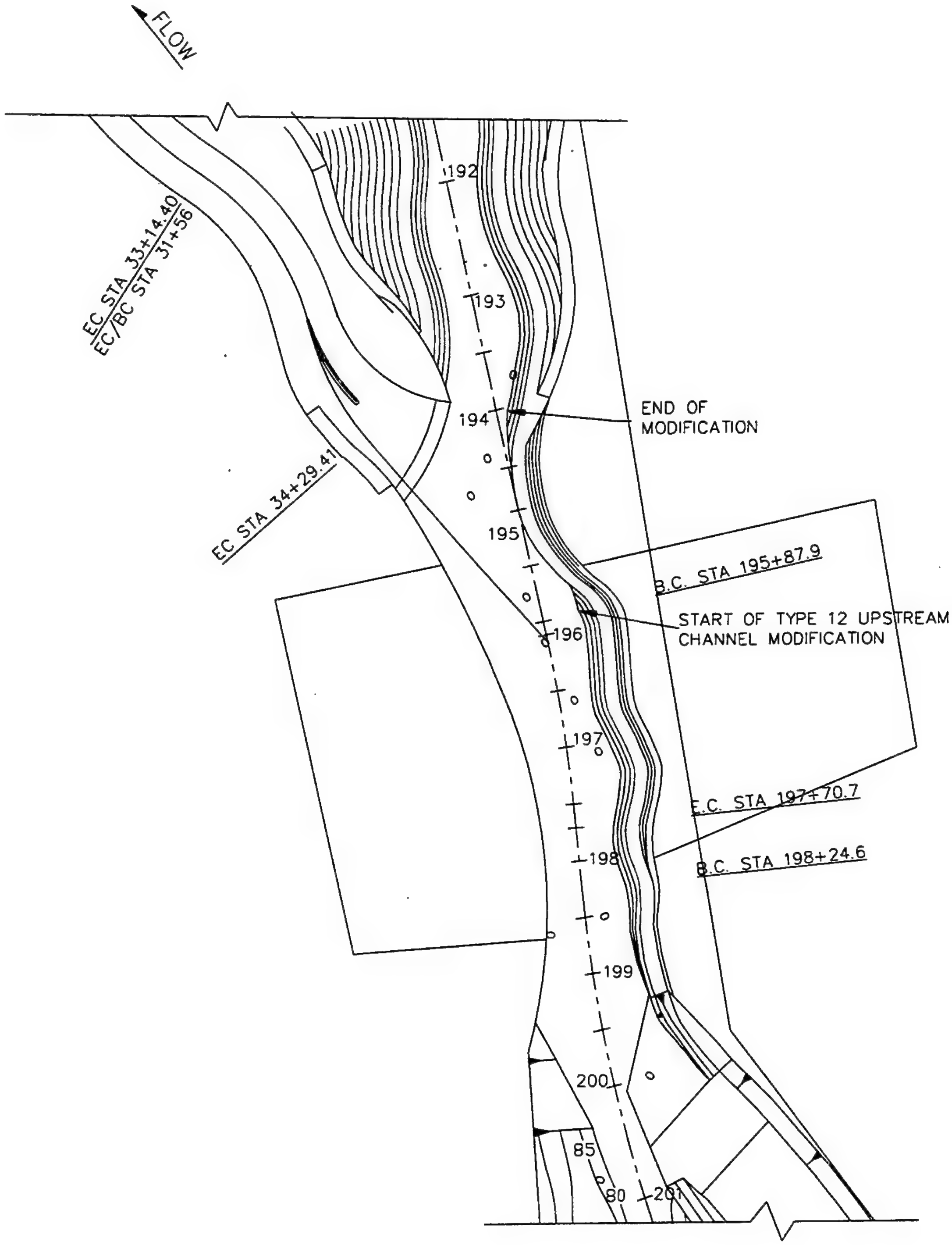



TYPE 5 BYPASS ENTRANCE
TYPE 11 UPSTREAM CHANNEL

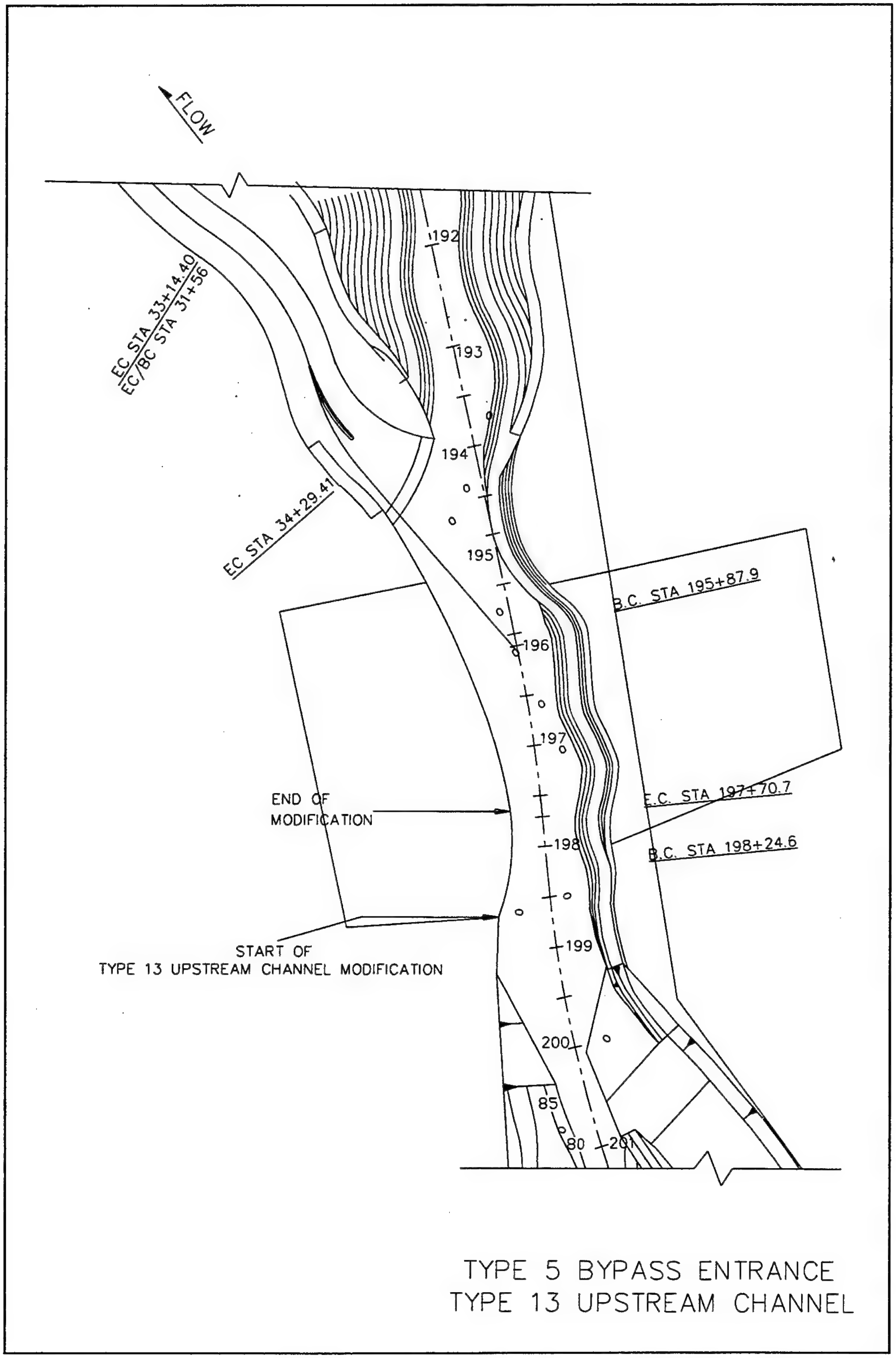

COMPARISON OF WATER-SURFACE PROFILES
TYPE 5 BYPASS ENTRANCE
TYPE 11 UPSTREAM CHANNEL
DISCHARGE 14,600 CFS
EXISTING CONDITIONS NO PIER EXTENSIONS
FUTURE CONDITIONS NO PIER EXTENSIONS
EXISTING CONDITIONS TYPE 1 PIER EXTENSIONS
FUTURE CONDITIONS TYPE 1 PIER EXTENSIONS
WATER-SURFACE EL
STATIONS
94
92
90
88
86
84
200+00
198+00
196+00
194+00
192+00

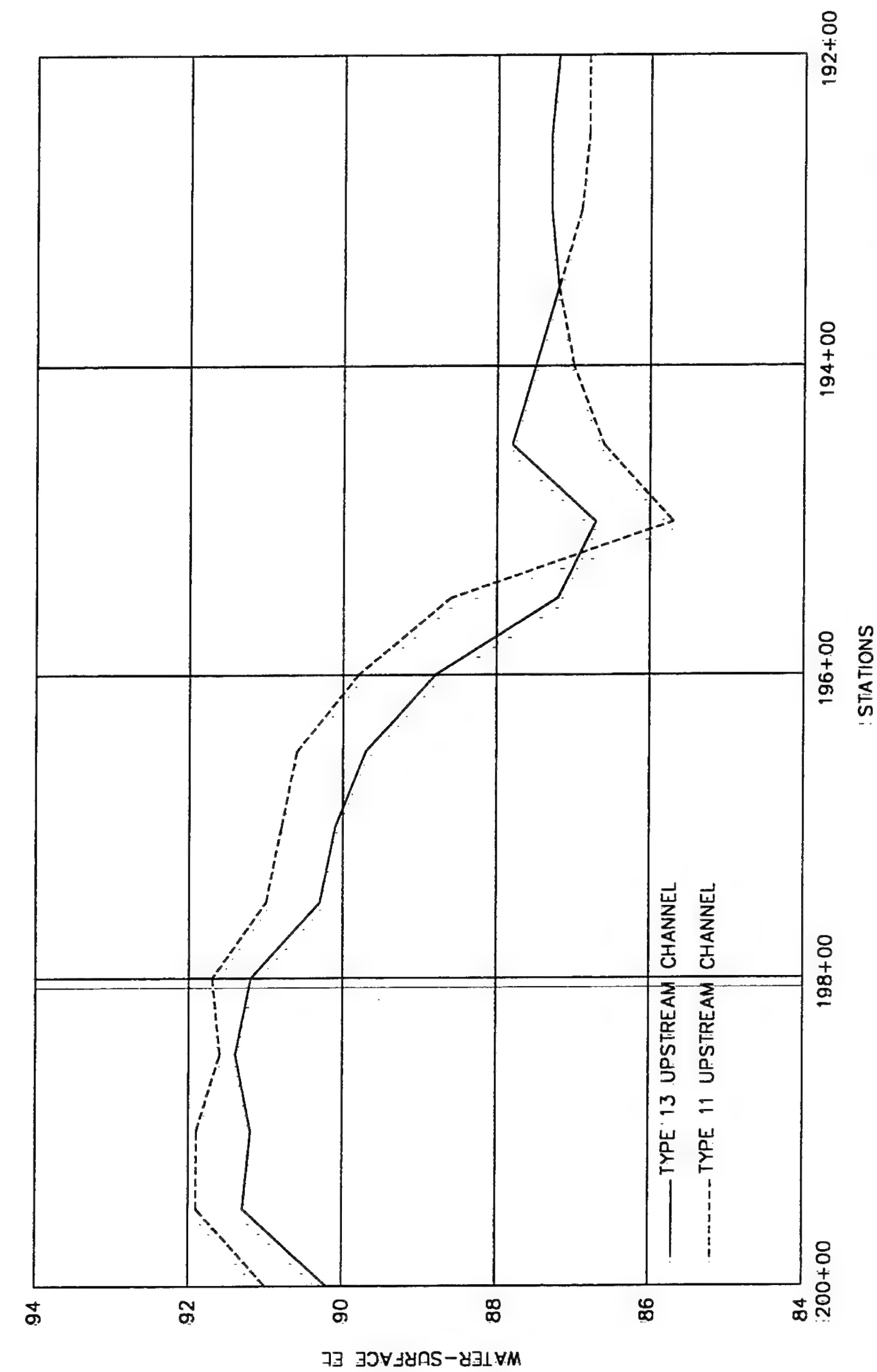



WATER-SURFACE PROFILES WITH PIER EXTENSIONS
TYPE 11 U/S CHANNEL, TYPE 5 BYPASS ENTRANCE
FUTURE CONDITIONS
DISCHARGE 14,600 CFS

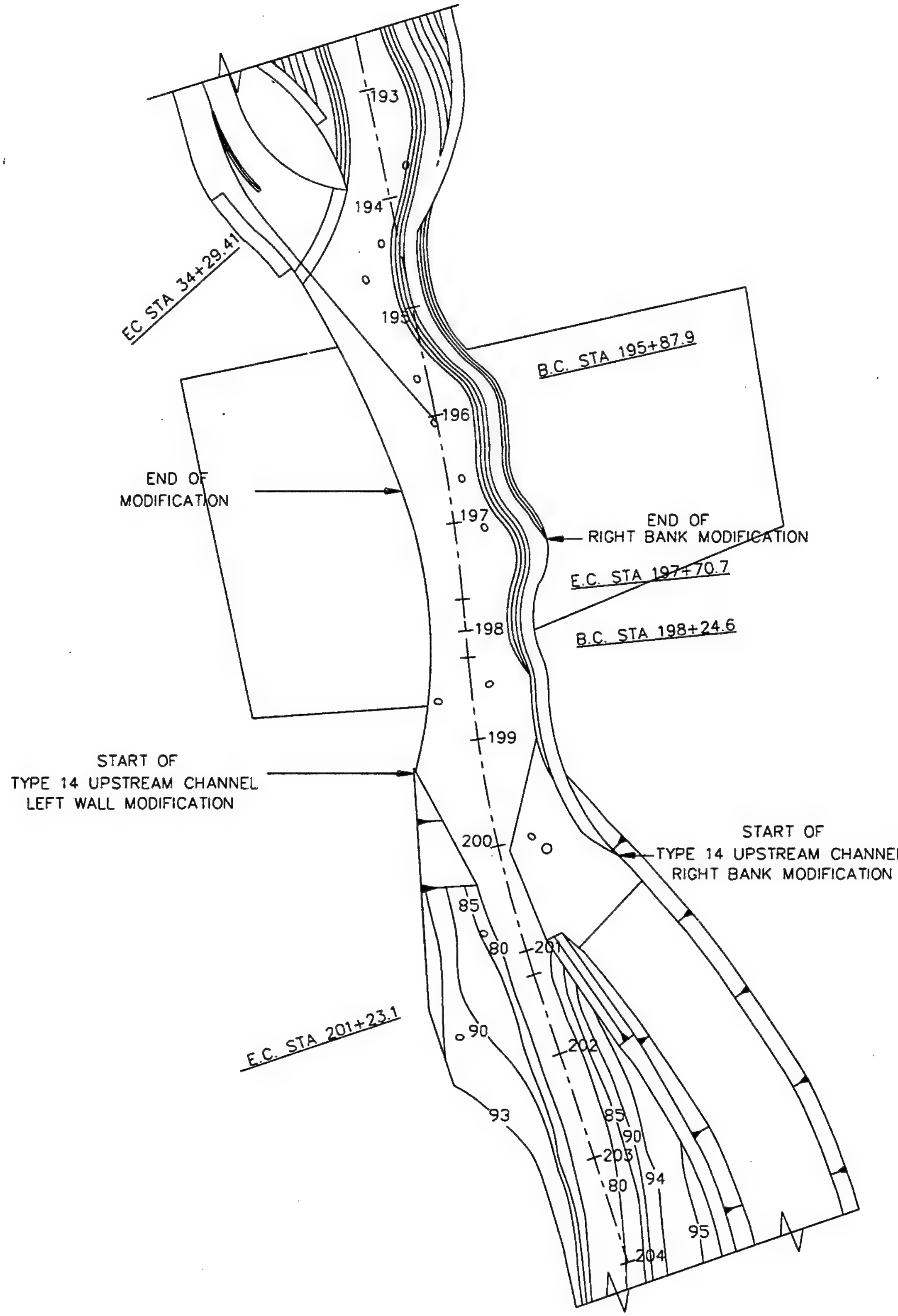



TYPE 5 BYPASS ENTRANCE
TYPE 12 UPSTREAM CHANNEL

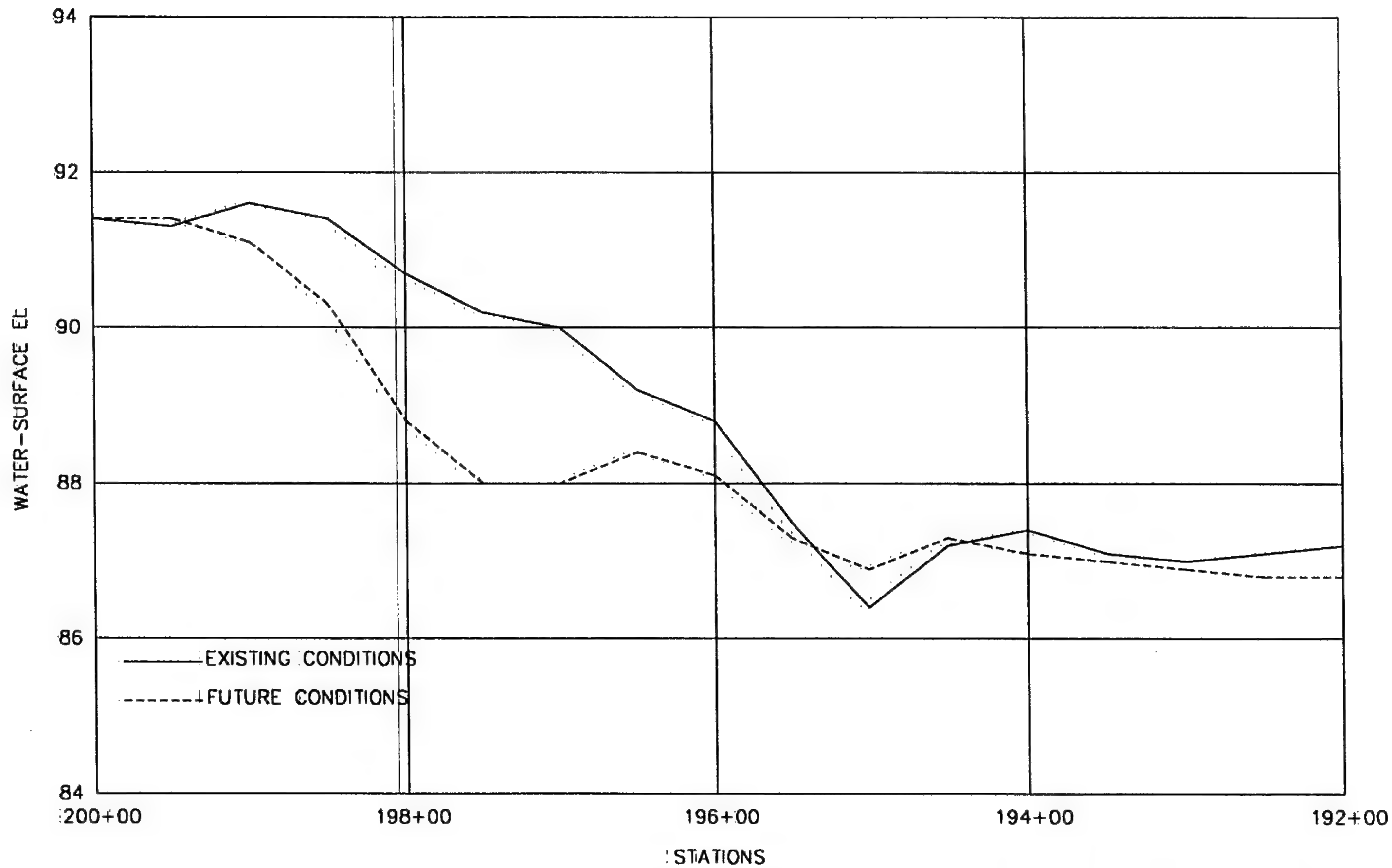

FLOW
EC STA 33+14.40
EC/BC STA 31+56
EC STA 34+29.41
192
193
194
195
196
197
198
199
200
85
80
201
B.C. STA 195+87.9
E.C. STA 197+70.7
B.C. STA 198+24.6
END OF
MODIFICATION
START OF
TYPE 13 UPSTREAM CHANNEL MODIFICATION
TYPE 5 BYPASS ENTRANCE
TYPE 13 UPSTREAM CHANNEL



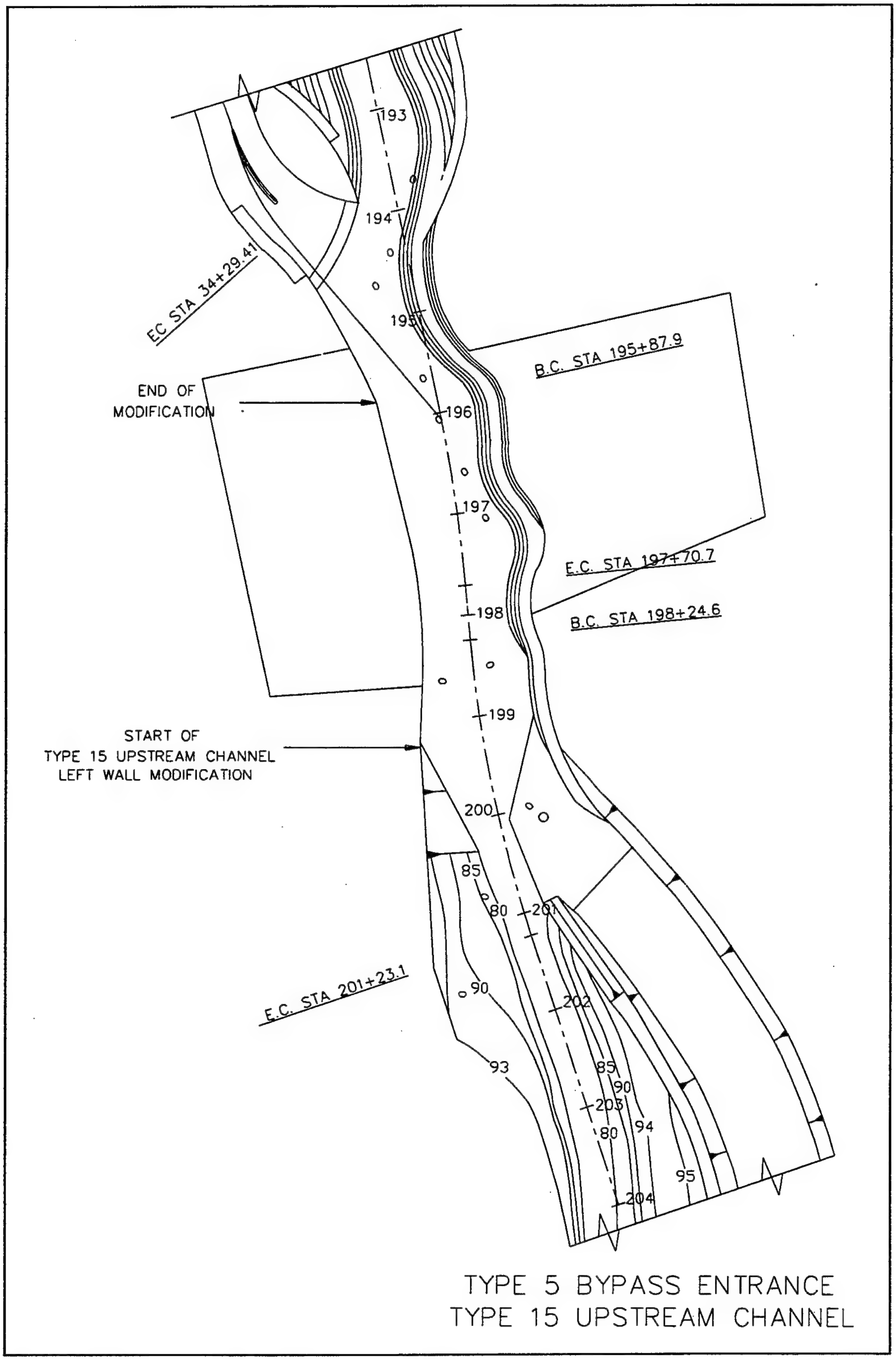

WATER-SURFACE PROFILES WITH TYPE 1 PIER EXTENSIONS
TYPE 5 BYPASS ENTRANCE
EXISTING CONDITIONS
DISCHARGE 14,600 CFS

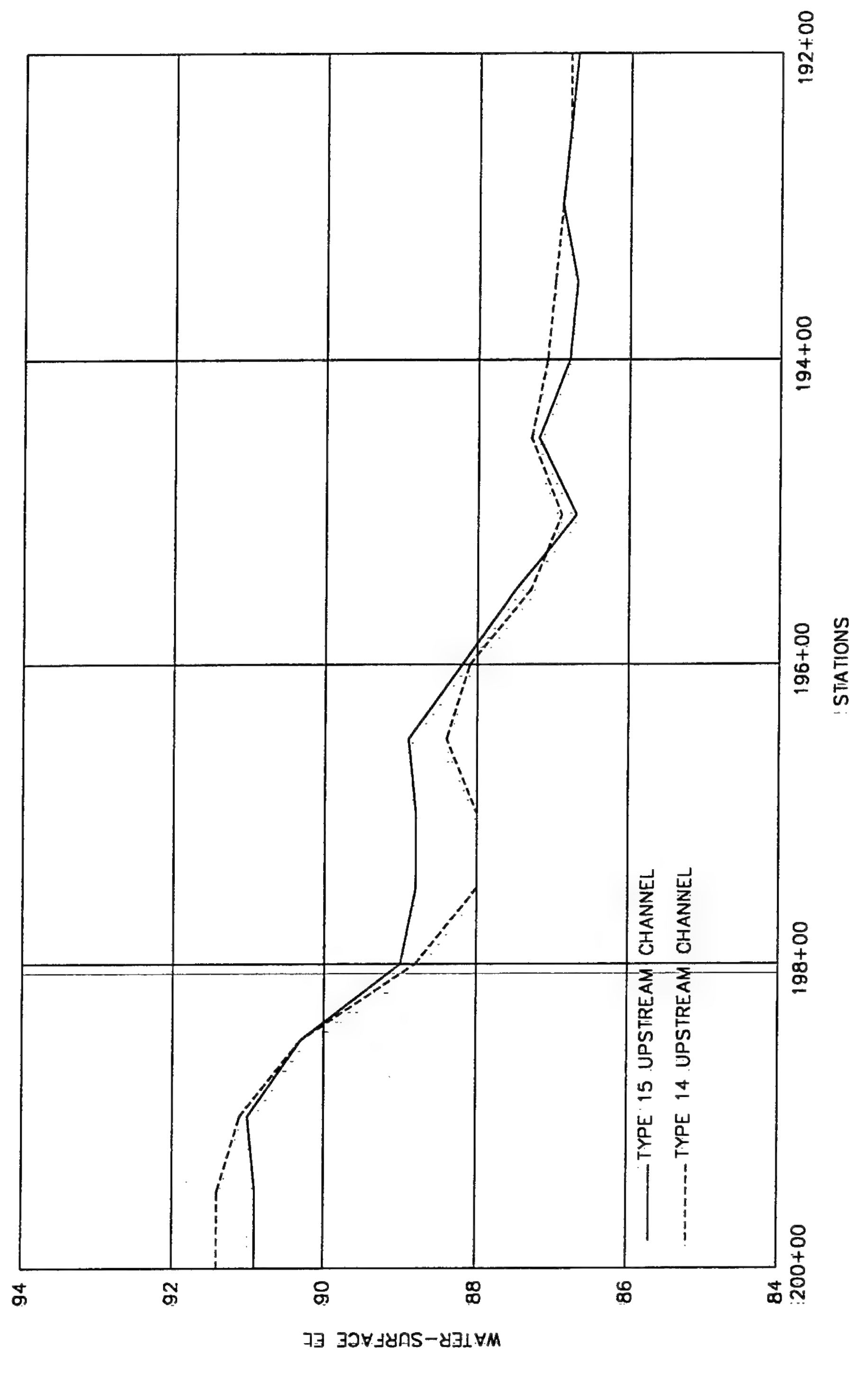



TYPE 5 BYPASS ENTRANCE
TYPE 14 UPSTREAM CHANNEL

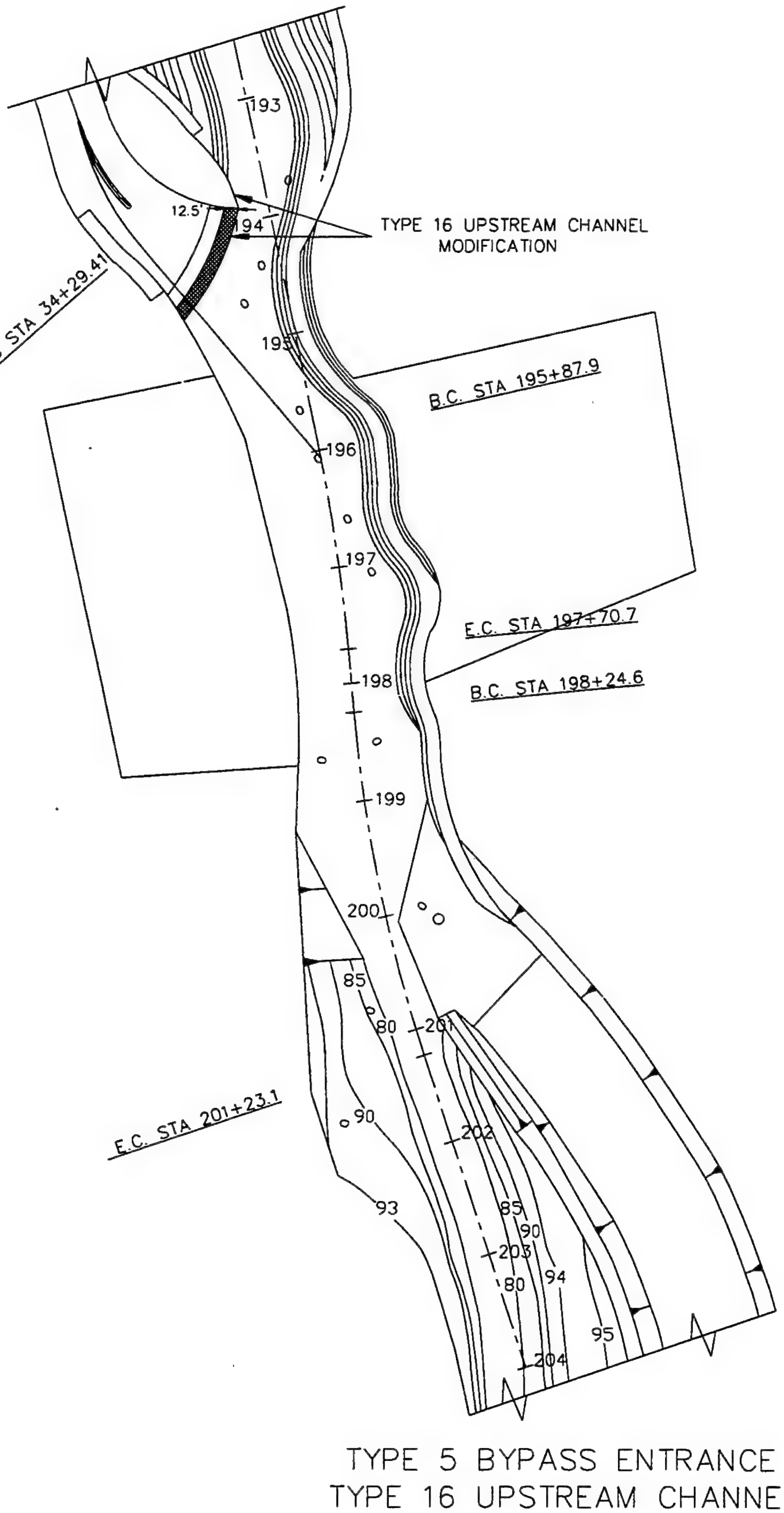



WATER-SURFACE PROFILES
TYPE 14 U/S CHANNEL, TYPE 5 BYPASS ENTRANCE
TYPE 5 PIER EXTENSIONS
DISCHARGE 14,600 CFS

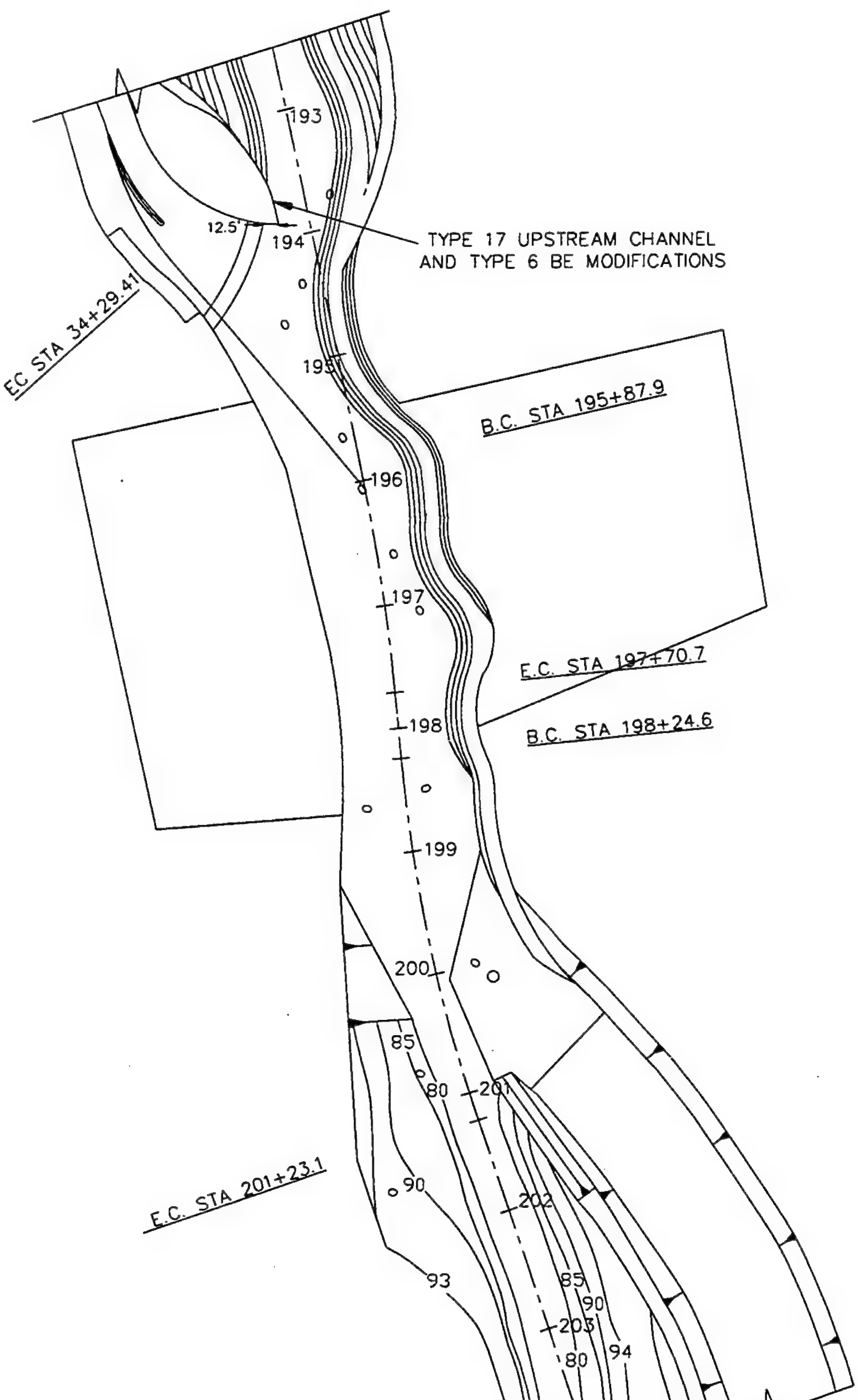

193
194
195
196
197
198
199
200
201
202
203
204
EC STA 34+29.41
B.C. STA 195+87.9
END OF
MODIFICATION
E.C. STA 197+70.7
B.C. STA 198+24.6
START OF
TYPE 15 UPSTREAM CHANNEL
LEFT WALL MODIFICATION
85
80
90
93
E.C. STA 201+23.1
85
90
94
80
95
TYPE 5 BYPASS ENTRANCE
TYPE 15 UPSTREAM CHANNEL



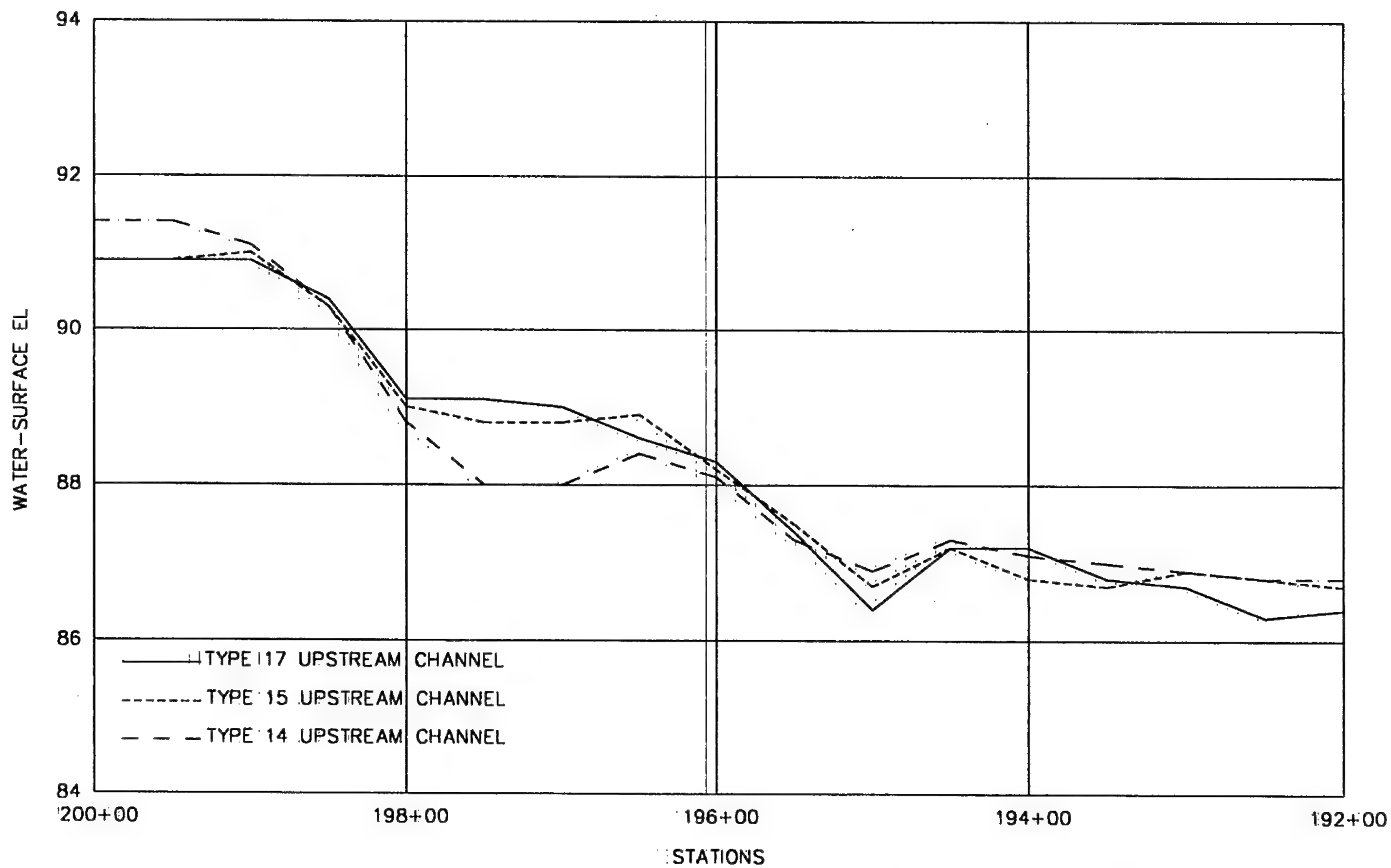

WATER-SURFACE PROFILES
TYPE 5 BYPASS ENTRANCE, TYPE 5 PIER EXTENSIONS
FUTURE CONDITIONS
DISCHARGE 14,600 CFS



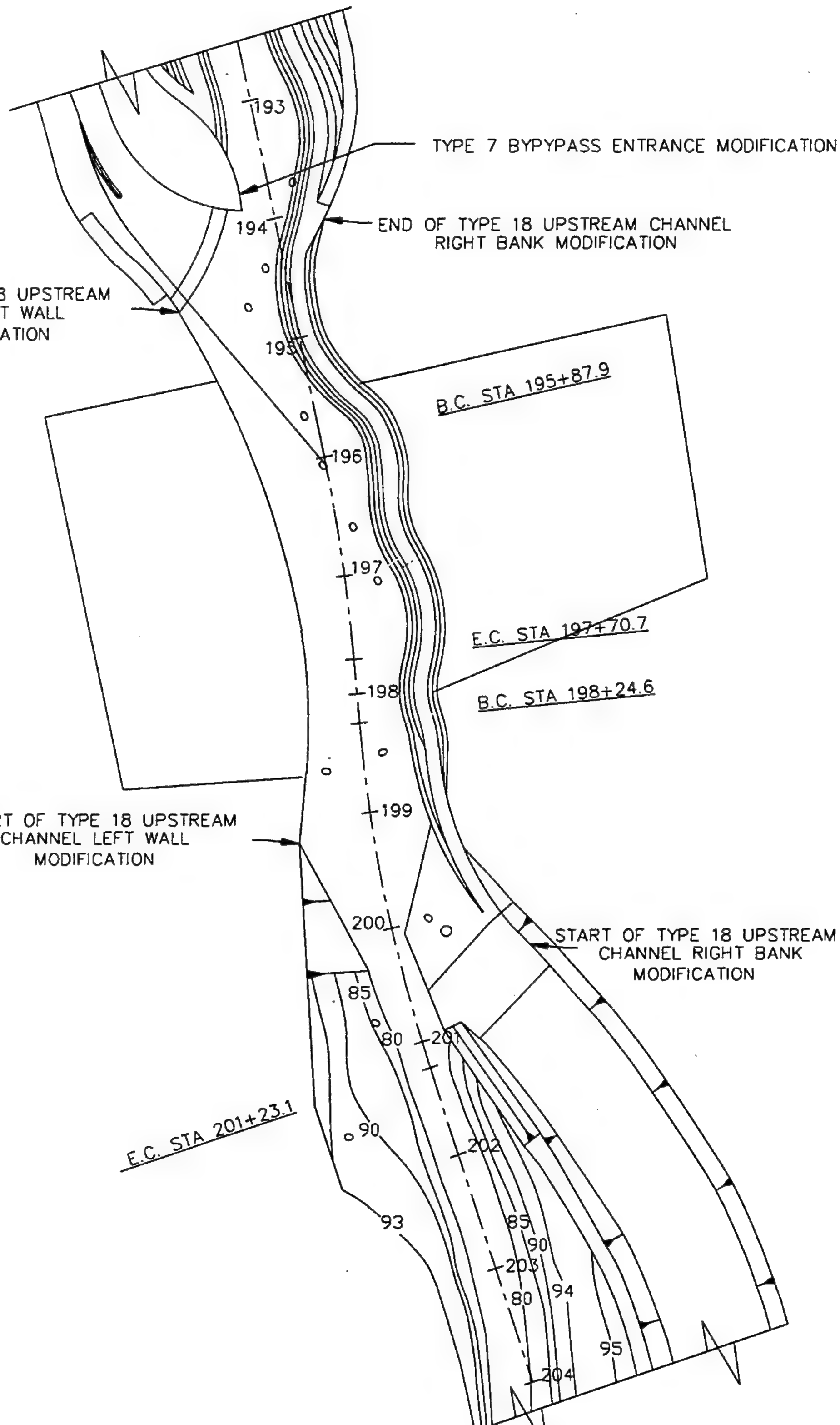

TYPE 5 BYPASS ENTRANCE
TYPE 16 UPSTREAM CHANNEL



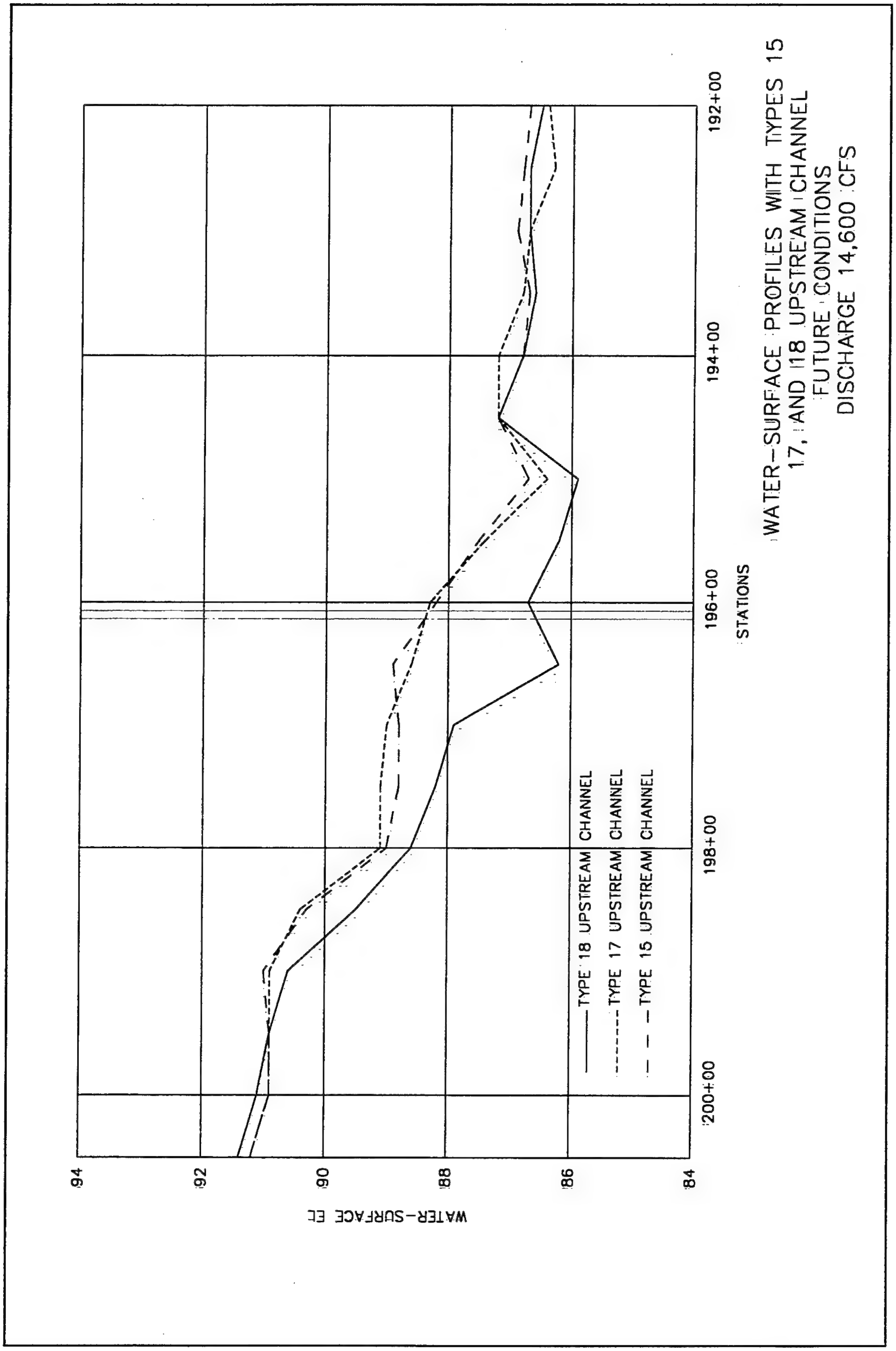

TYPE 6 BYPASS ENTRANCE
TYPE 17 UPSTREAM CHANNEL

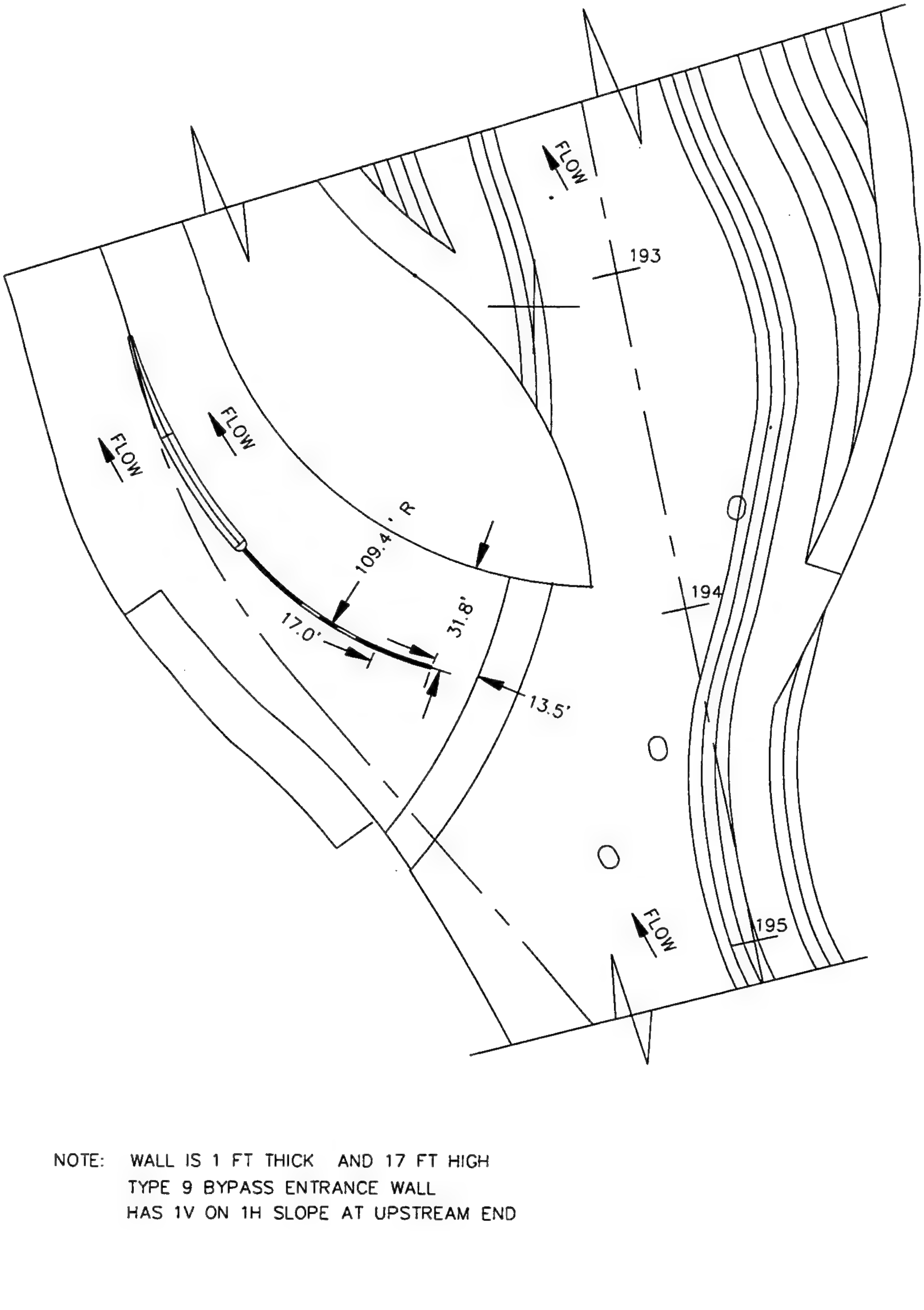



WATER-SURFACE PROFILES WITH TYPE 5 PIER EXTENSIONS
TYPES 5 AND 6 BYPASS ENTRANCE
FUTURE CONDITIONS
DISCHARGE 114,600 CFS



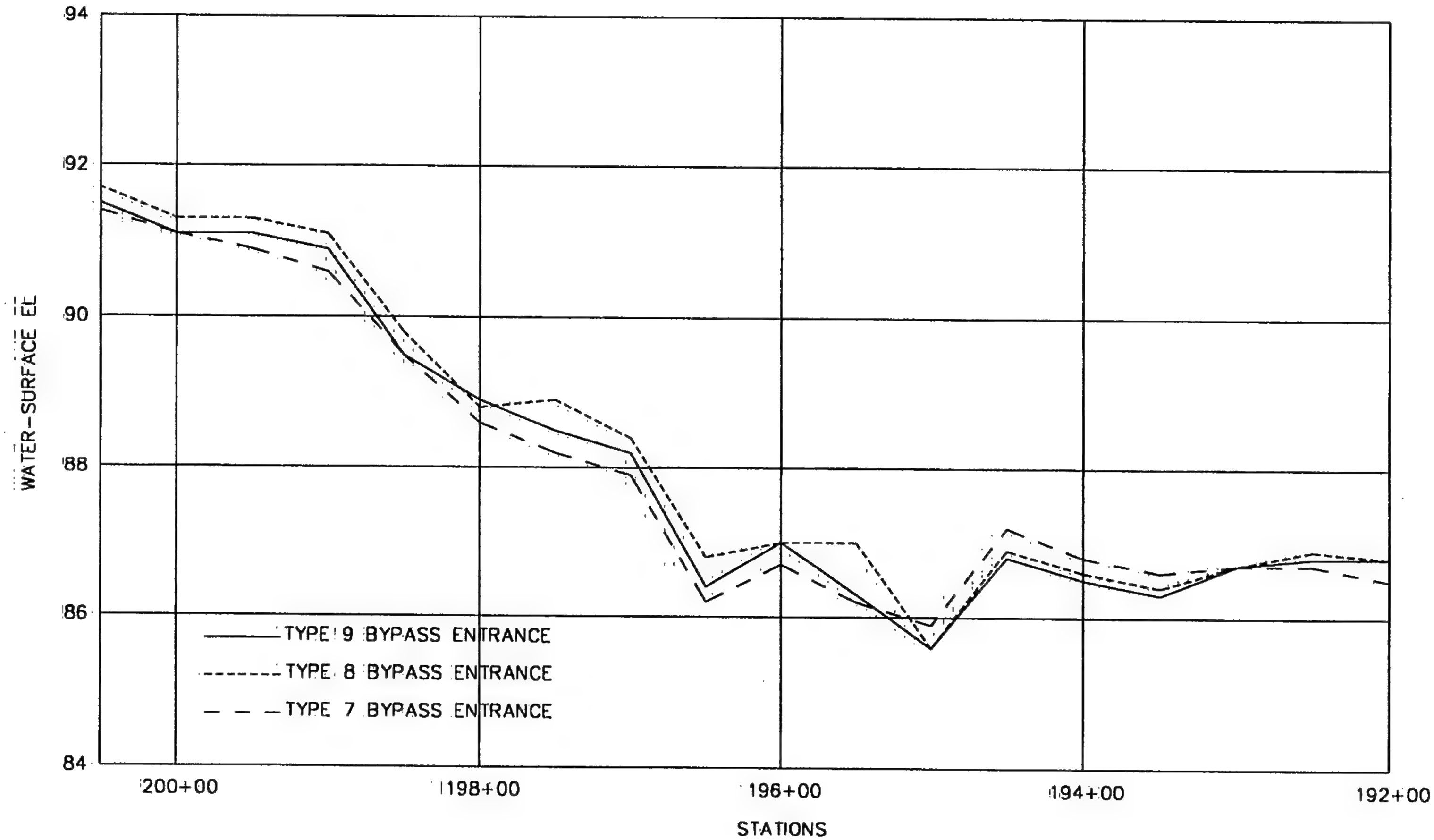

TYPE 7 BYPASS ENTRANCE
TYPE 18 UPSTREAM CHANNEL


WATER-SURFACE PROFILES WITH TYPES 15
17, AND 18 UPSTREAM CHANNEL
FUTURE CONDITIONS
DISCHARGE 14,600 CFS
TYPE 18 UPSTREAM CHANNEL
TYPE 17 UPSTREAM CHANNEL
TYPE 15 UPSTREAM CHANNEL
WATER-SURFACE EL
STATIONS
192+00
194+00
196+00
198+00
200+00
94
92
90
88
86
84

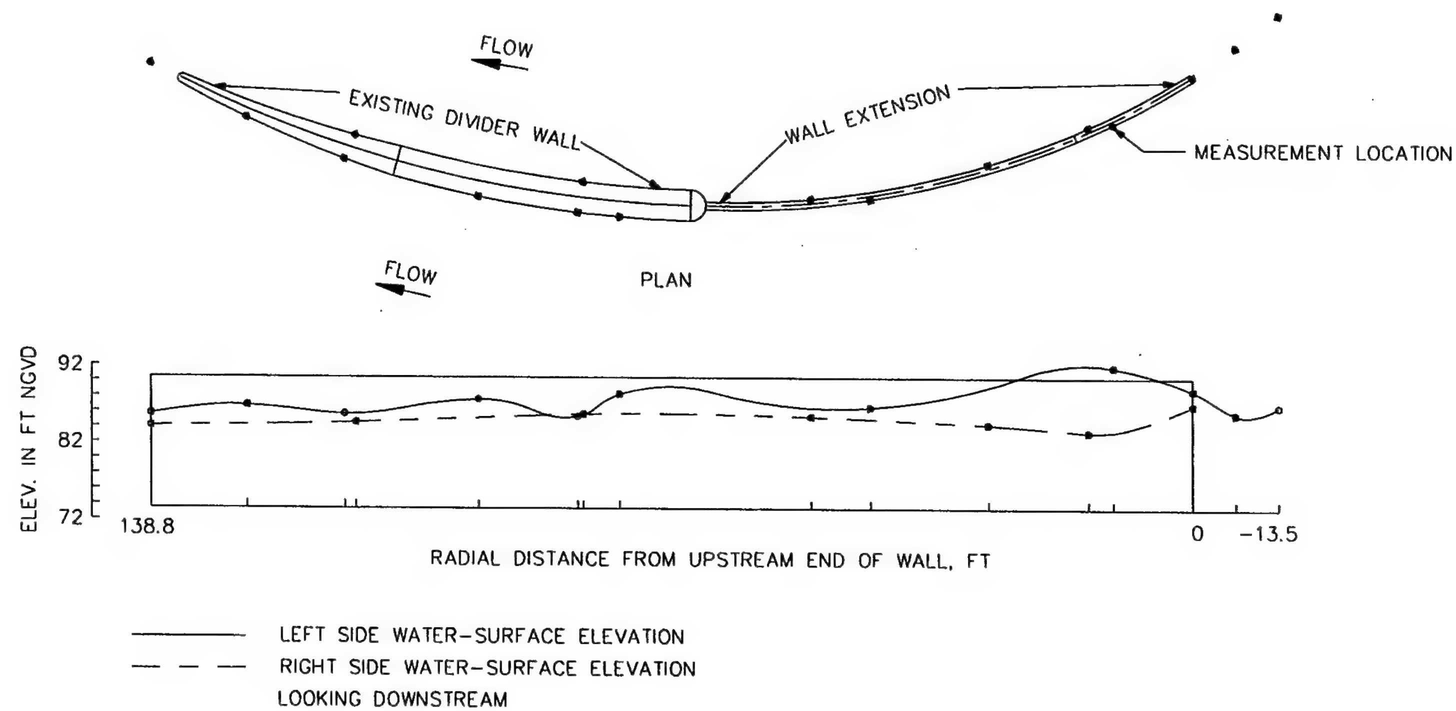



NOTE: WALL IS 1 FT THICK AND 17 FT HIGH
TYPE 9 BYPASS ENTRANCE WALL
HAS 1V ON 1H SLOPE AT UPSTREAM END

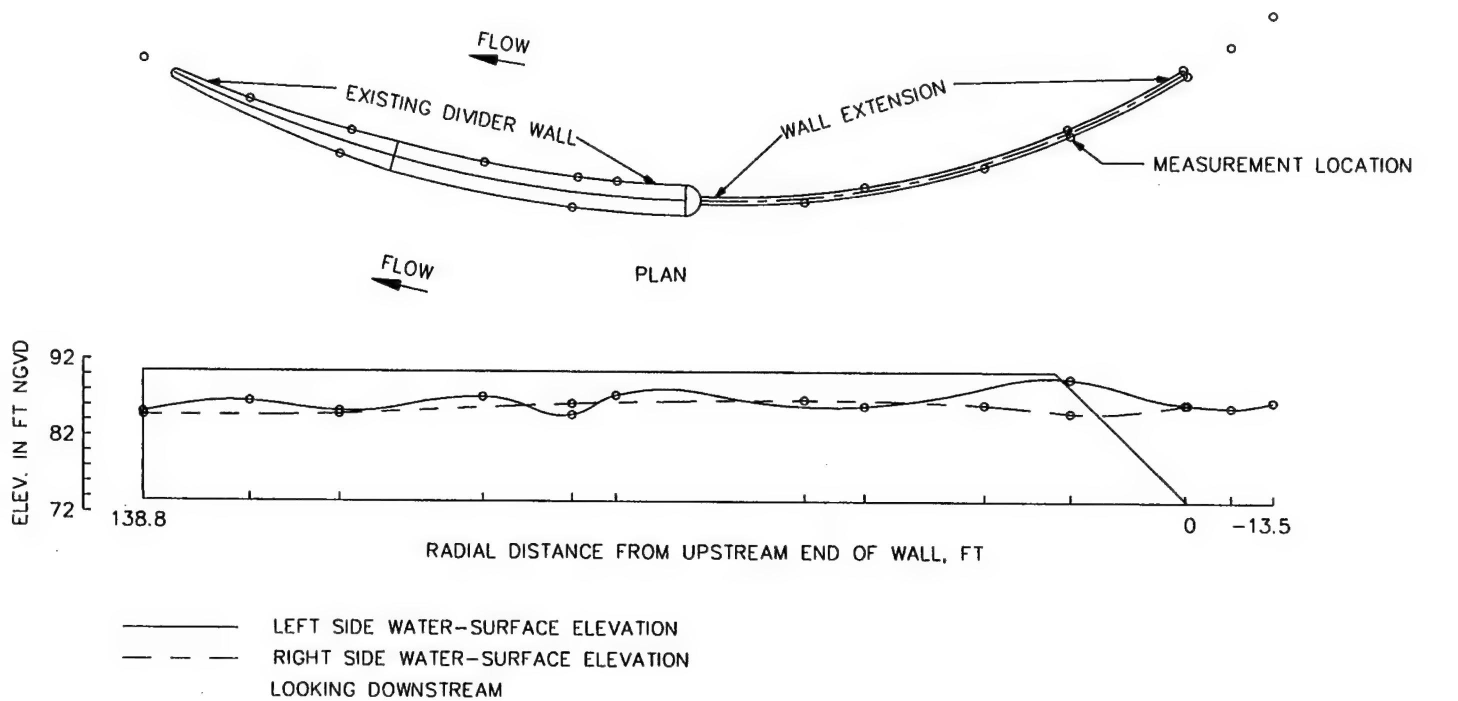
TYPES 8 AND 9 BYPASS ENTRANCE



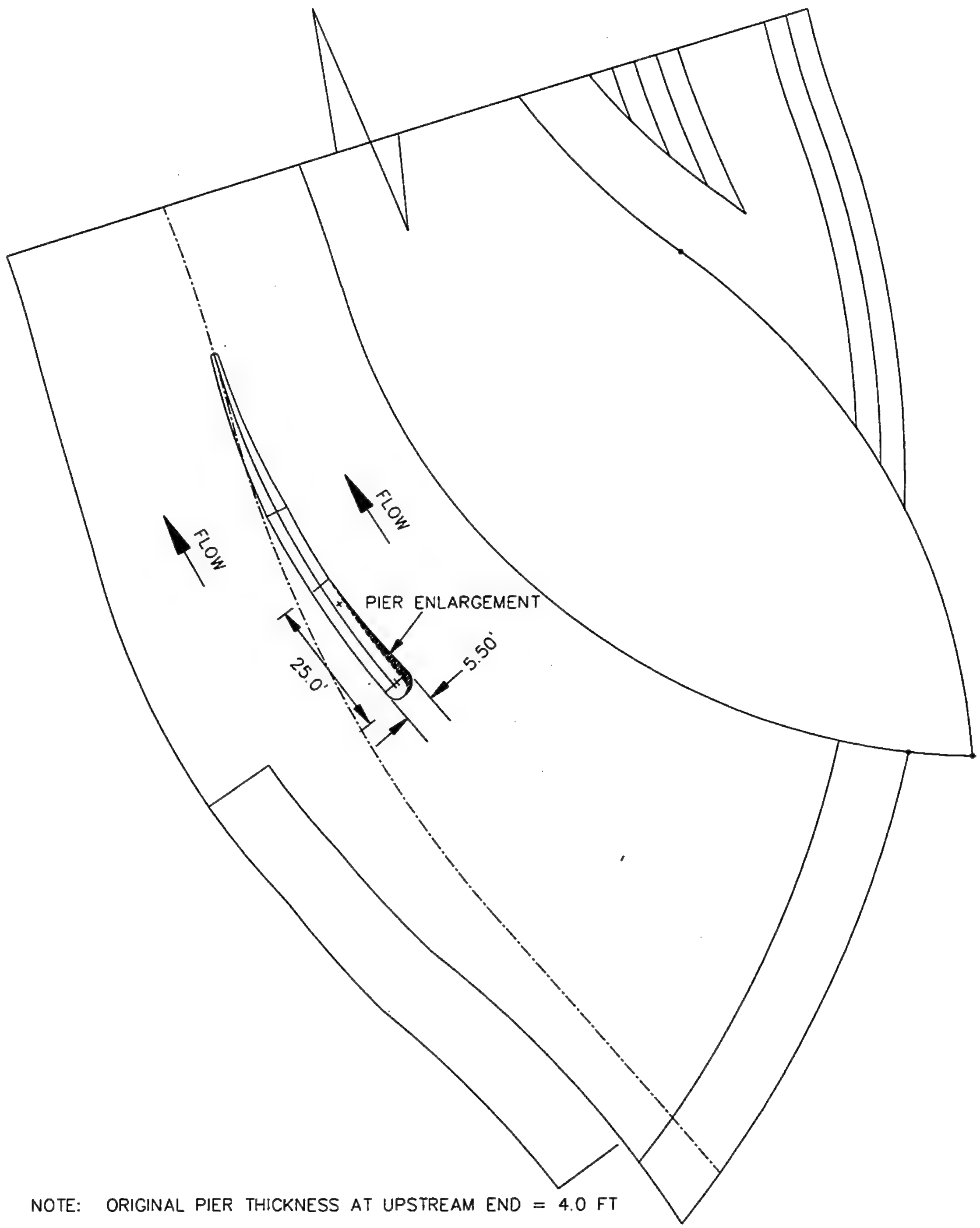

WATER-SURFACE PROFILES
TYPE 18 UPSTREAM CHANNEL, TYPE 6 PIER EXTENSIONS
FUTURE CONDITIONS
DISCHARGE 14,600 CFS




WATER-SURFACE PROFILES
TYPE 8 BYPASS ENTRANCE

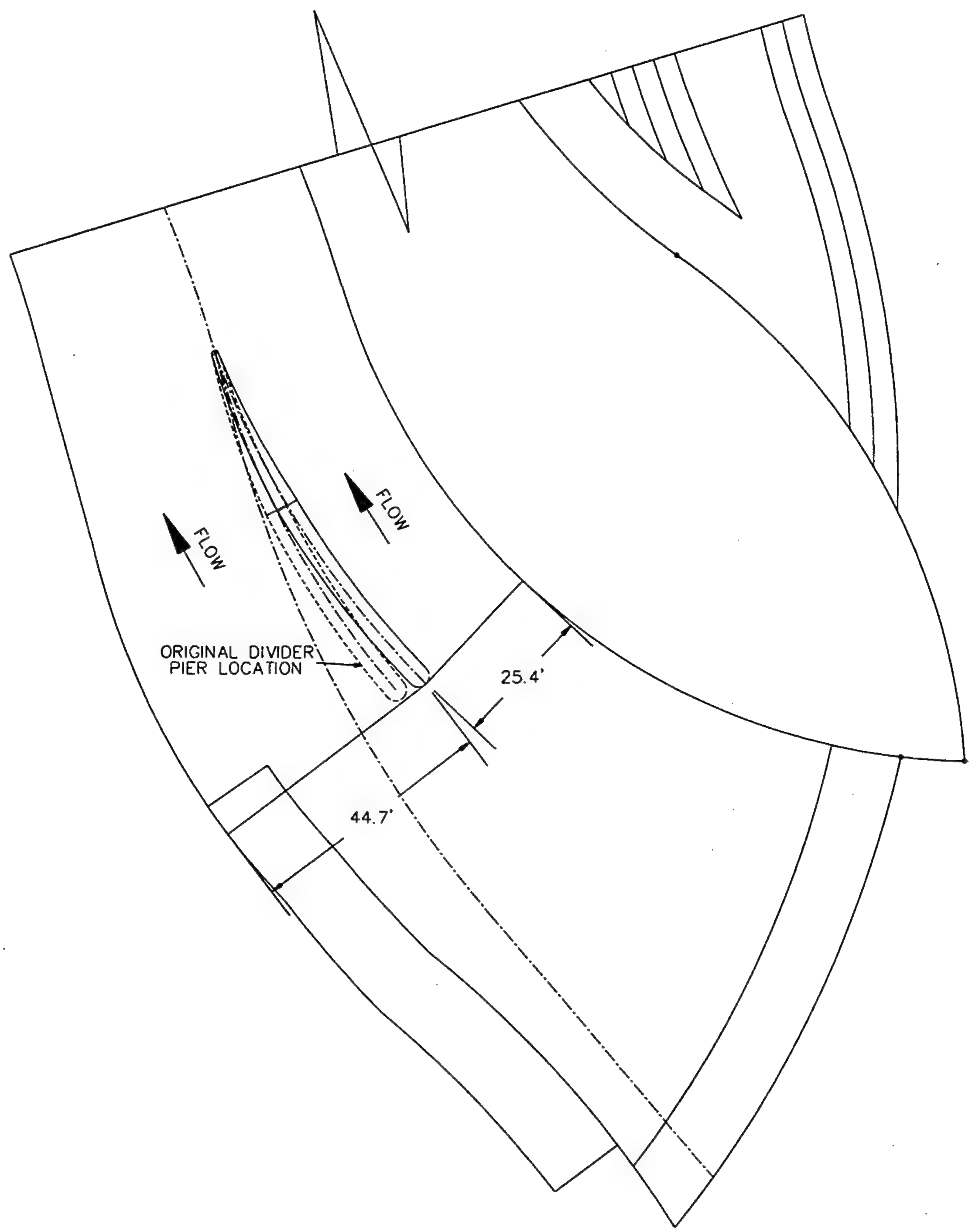



WATER-SURFACE PROFILES
TYPE 9 BYPASS ENTRANCE

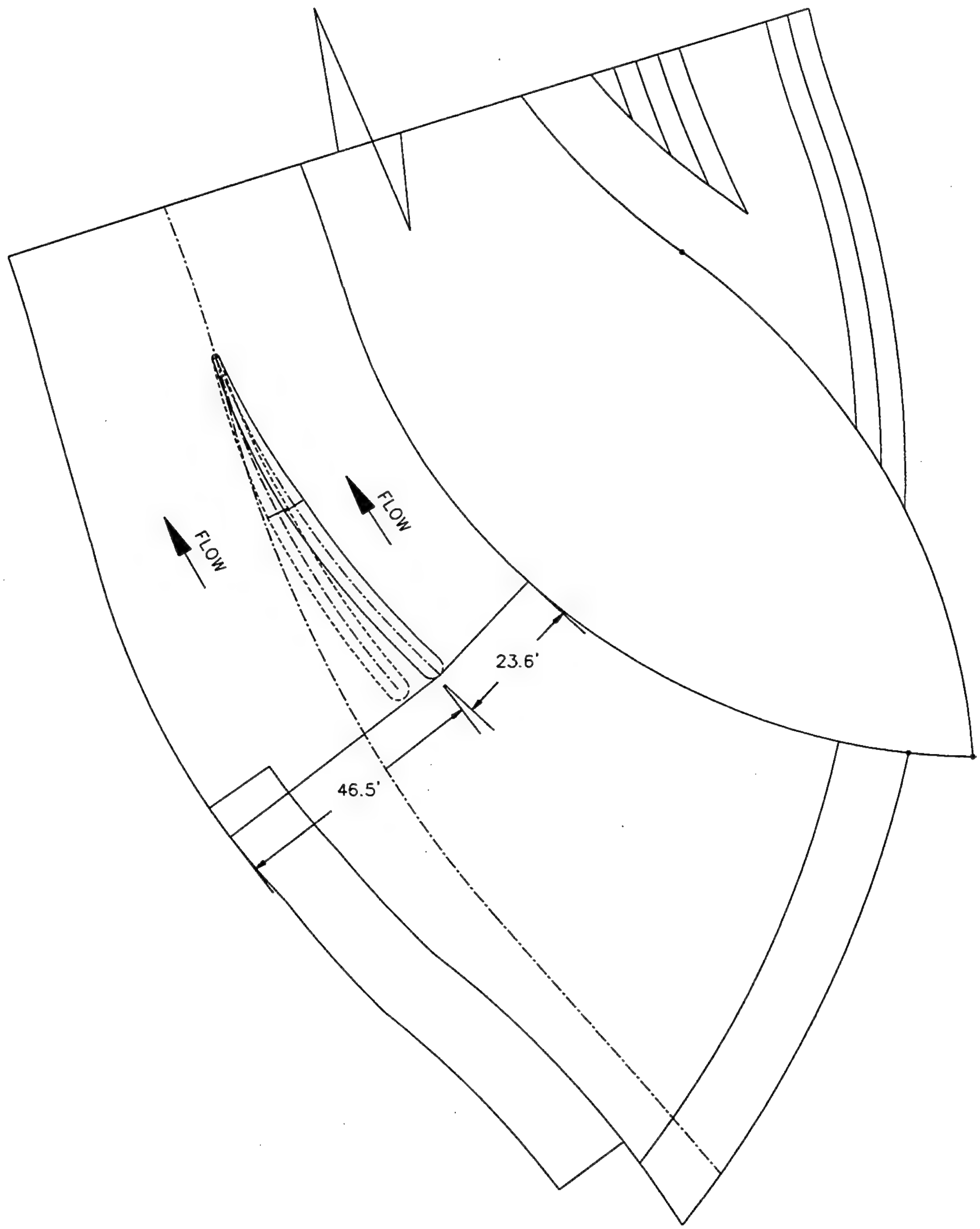



NOTE: ORIGINAL PIER THICKNESS AT UPSTREAM END = 4.0 FT

TYPE 10 BYPASS ENTRANCE

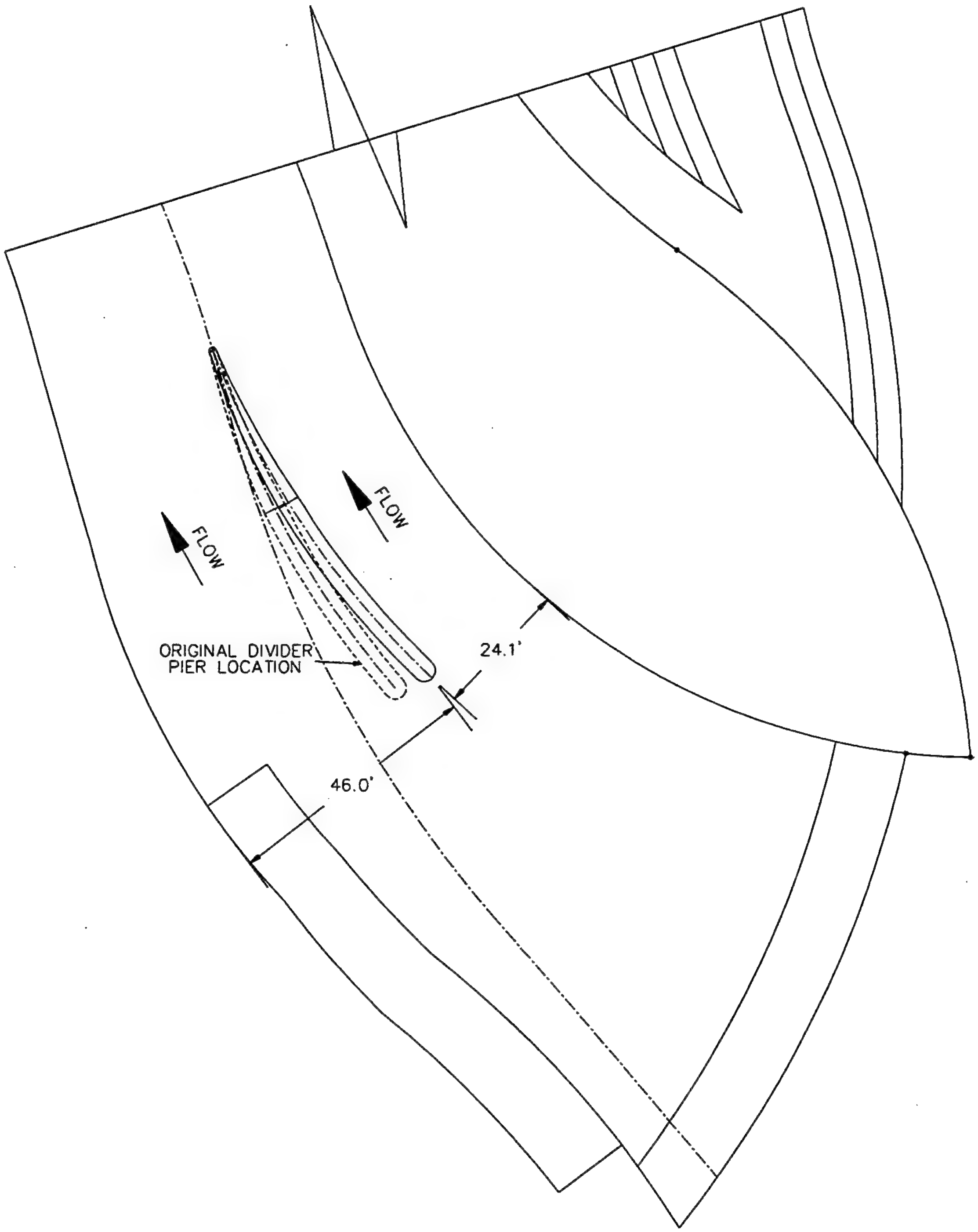


TYPE 11 BYPASS ENTRANCE

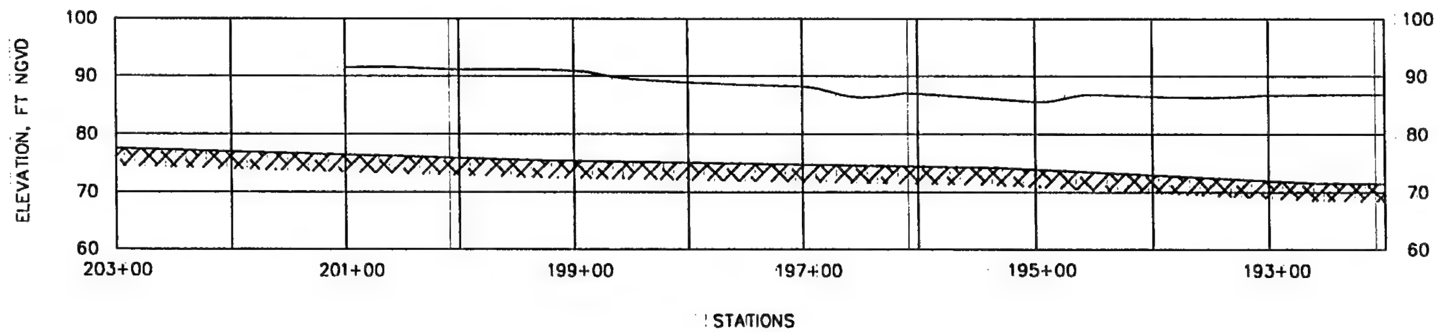


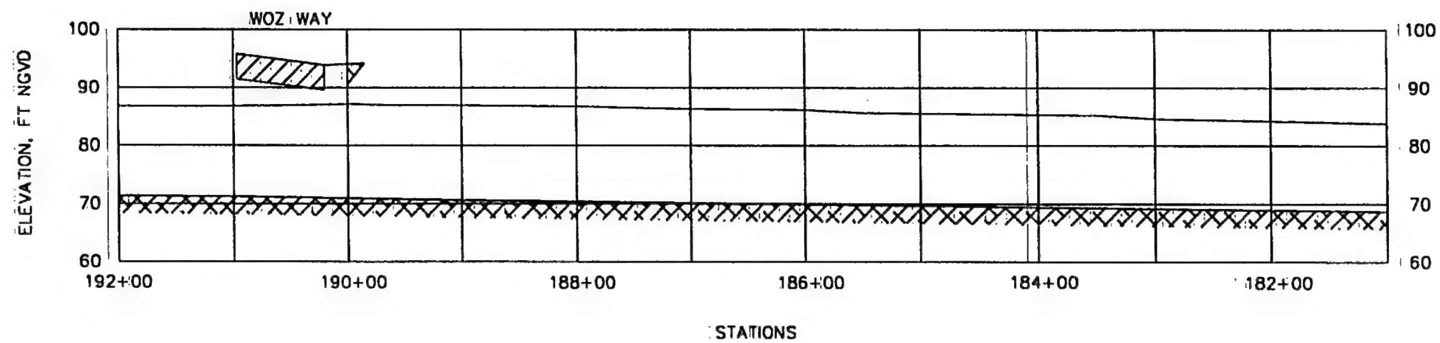

TYPE 12 BYPASS ENTRANCE

Plate 60




TYPE 13 BYPASS ENTRANCE

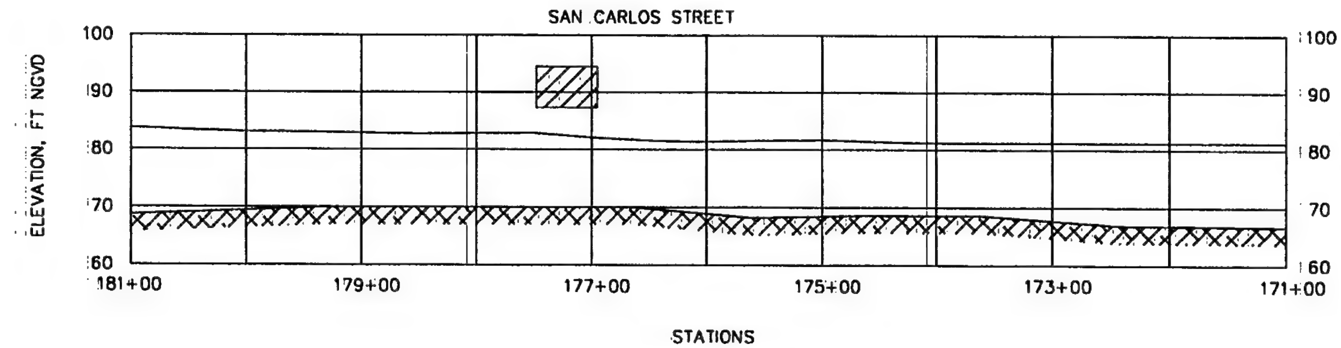


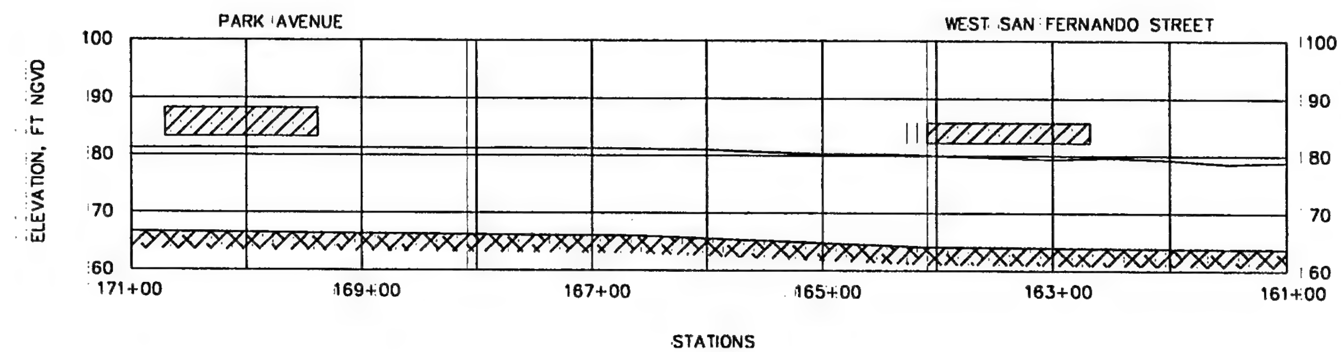




LEGEND

(REFERENCED TO LOOKING DOWNSTREAM)

STA 203+00 TO STA 181+00
TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS, DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT 151+27 = 77.0




LEGEND

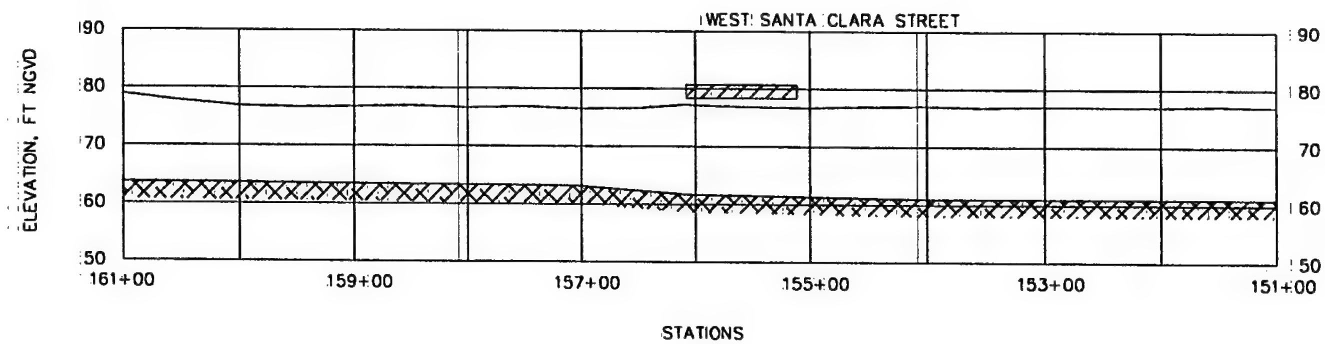
(REFERENCED TO LOOKING DOWNSTREAM)

STA 181+00 TO 161+00

TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.

FUTURE CONDITIONS, DISCHARGE 14,600 CFS

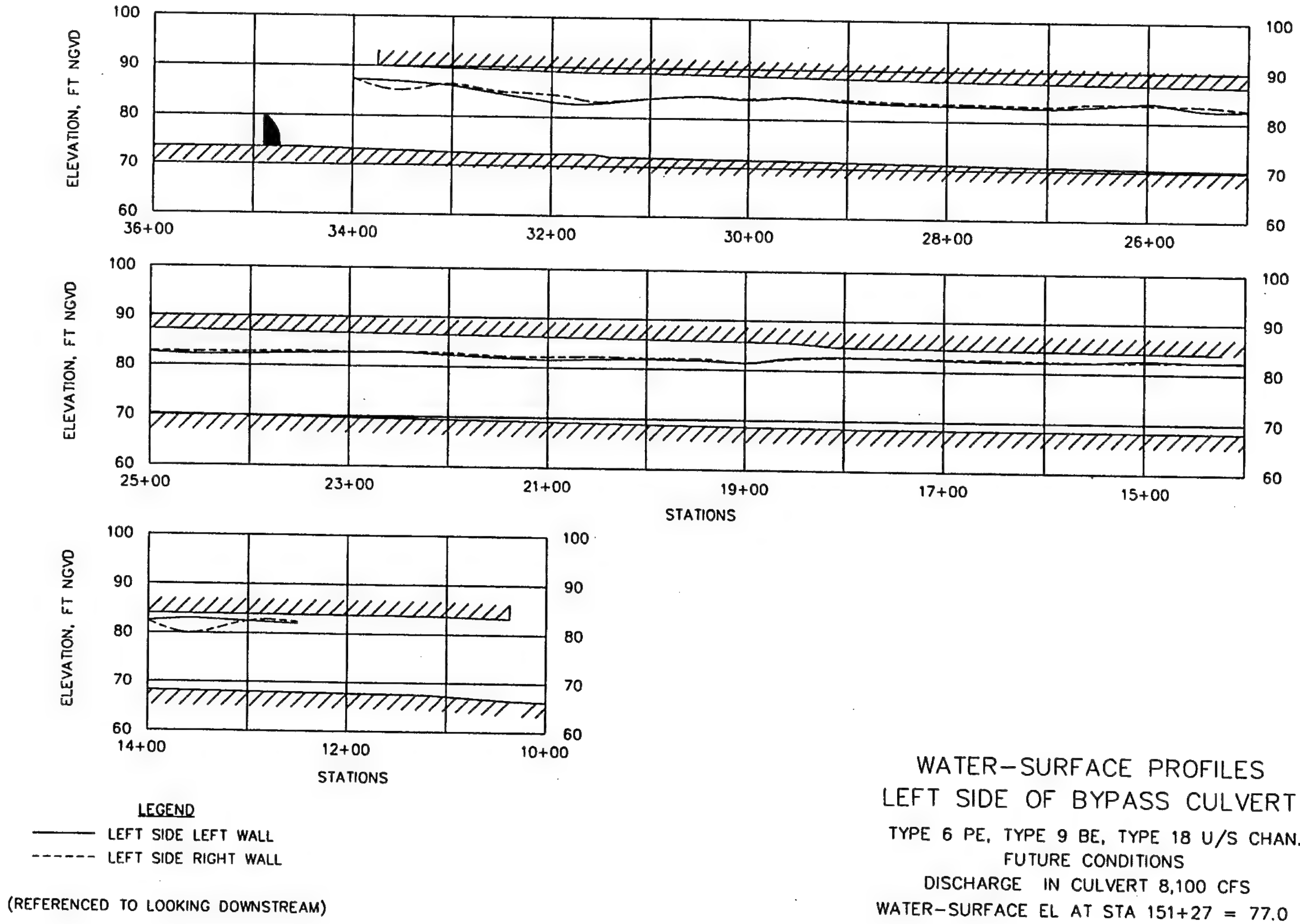
WATER-SURFACE ELEVATION AT STA 151+27 = 77.0



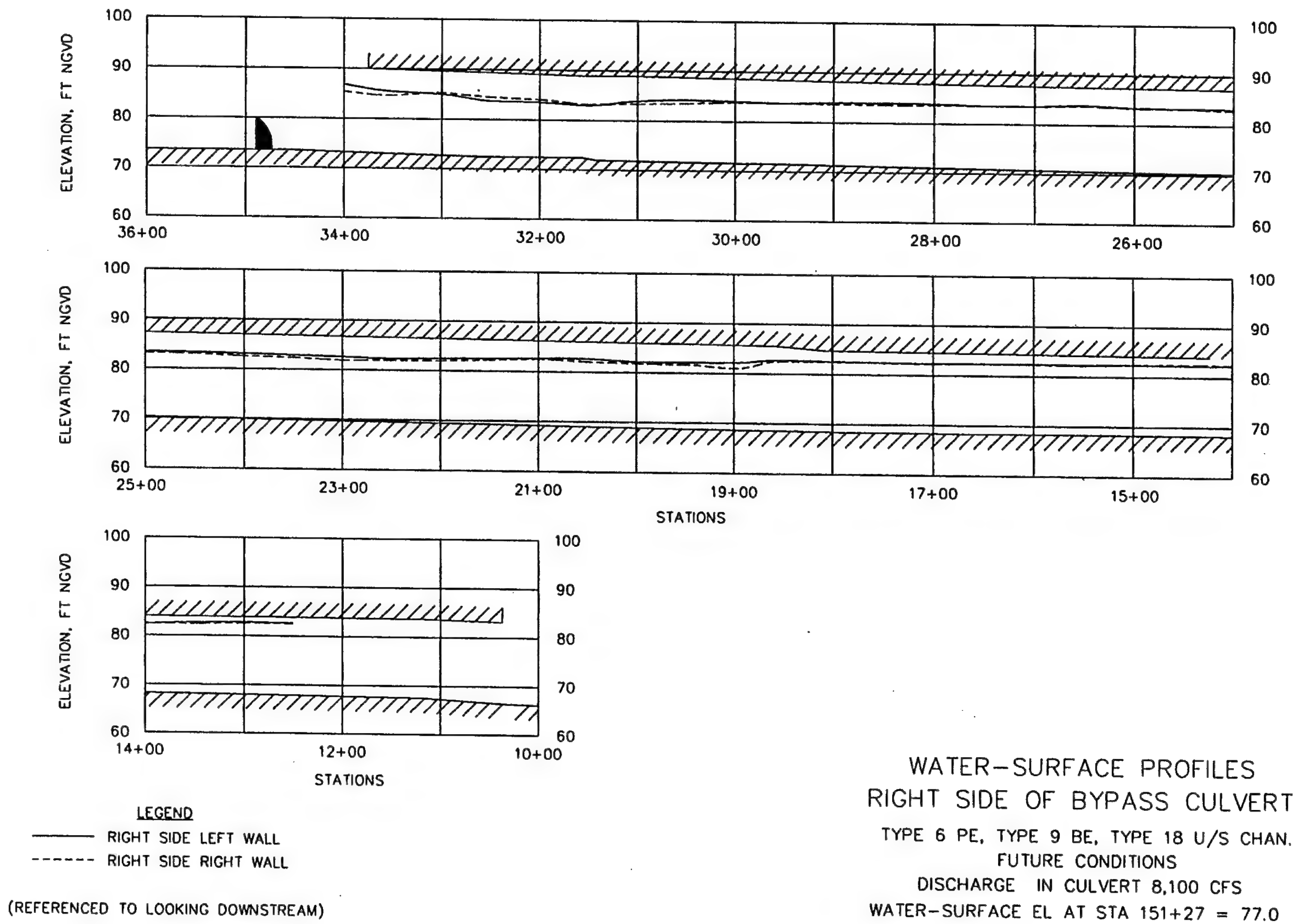

LEGEND

(REFERENCED TO LOOKING DOWNSTREAM)

STA 161+00 TO STA 151+00
TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS, DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT STA 151+27 = 77.0

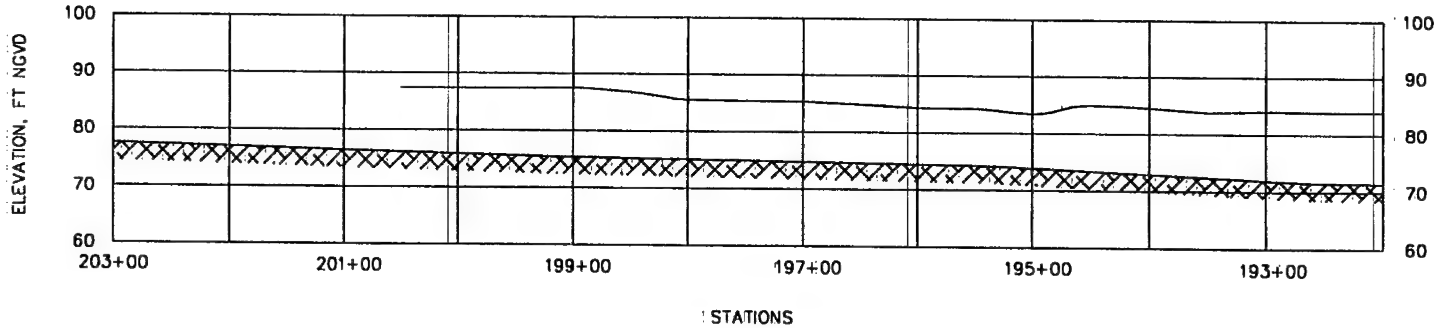


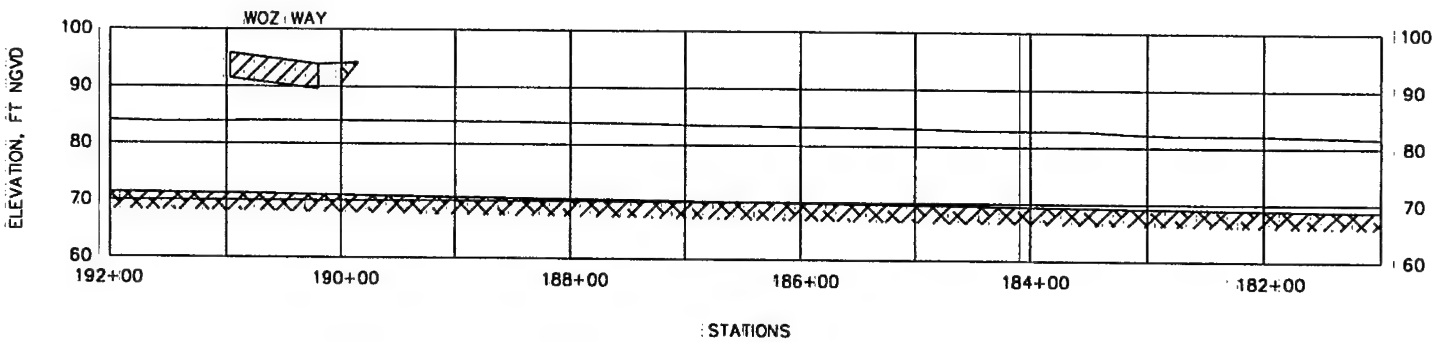

WATER–SURFACE PROFILES
LEFT SIDE OF BYPASS CULVERT
TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS
DISCHARGE IN CULVERT 8,100 CFS
WATER–SURFACE EL AT STA 151+27 = 77.0




WATER–SURFACE PROFILES
RIGHT SIDE OF BYPASS CULVERT

TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS
DISCHARGE IN CULVERT 8,100 CFS
WATER–SURFACE EL AT STA 151+27 = 77.0

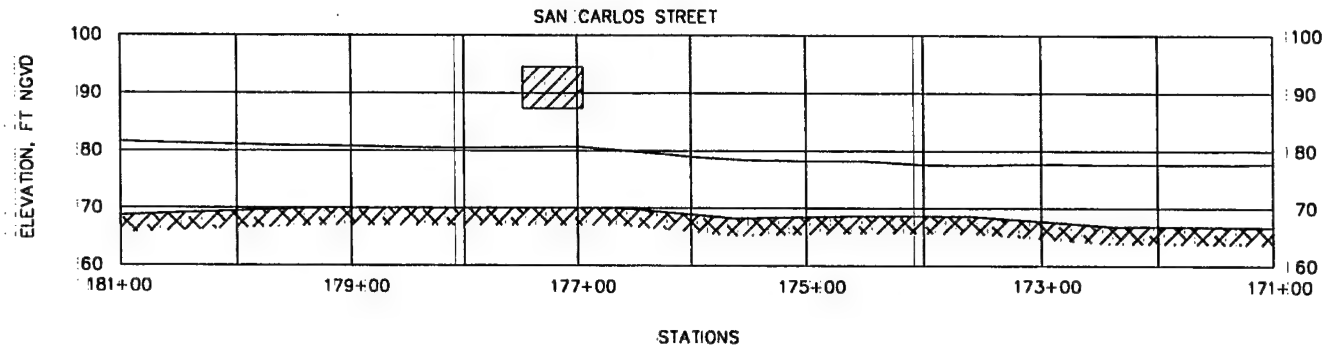


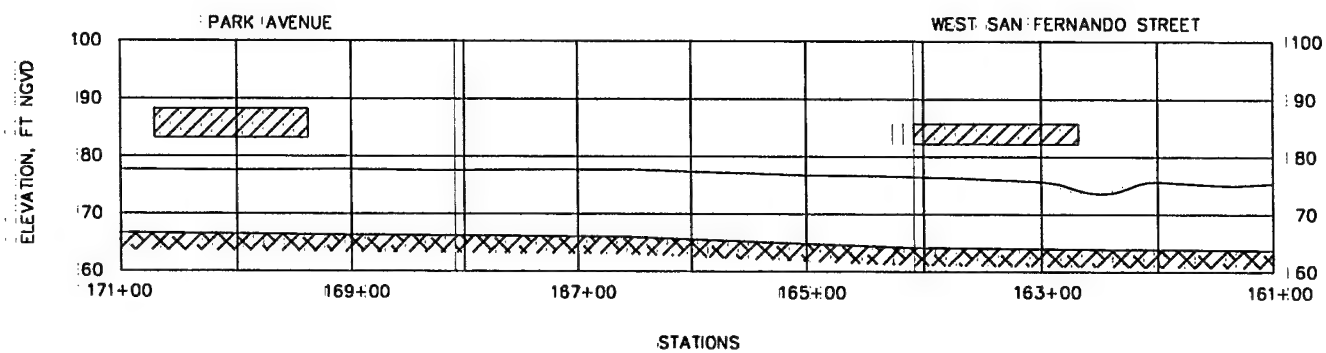




LEGEND

(REFERENCED TO LOOKING DOWNSTREAM)

STA 203+00 TO STA 181+00
TYPE 6 PE, TYPE 11 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS, DISCHARGE 9,100 CFS
WATER-SURFACE ELEVATION AT 151+27 = 73.6




LEGEND

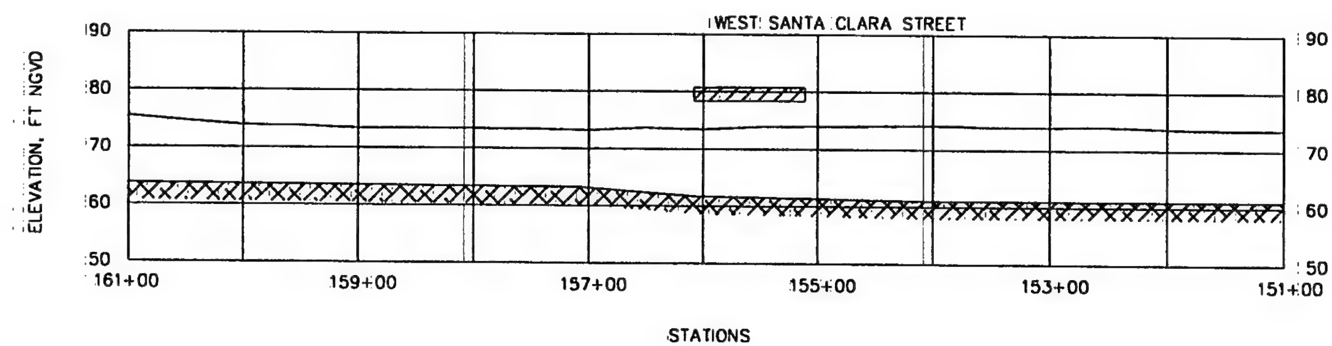
(REFERENCED TO LOOKING DOWNSTREAM)

STA 181+00 TO 161+00

TYPE 6 PE, TYPE 11 BE, TYPE 18 U/S CHAN.

FUTURE CONDITIONS, DISCHARGE 9,100 CFS

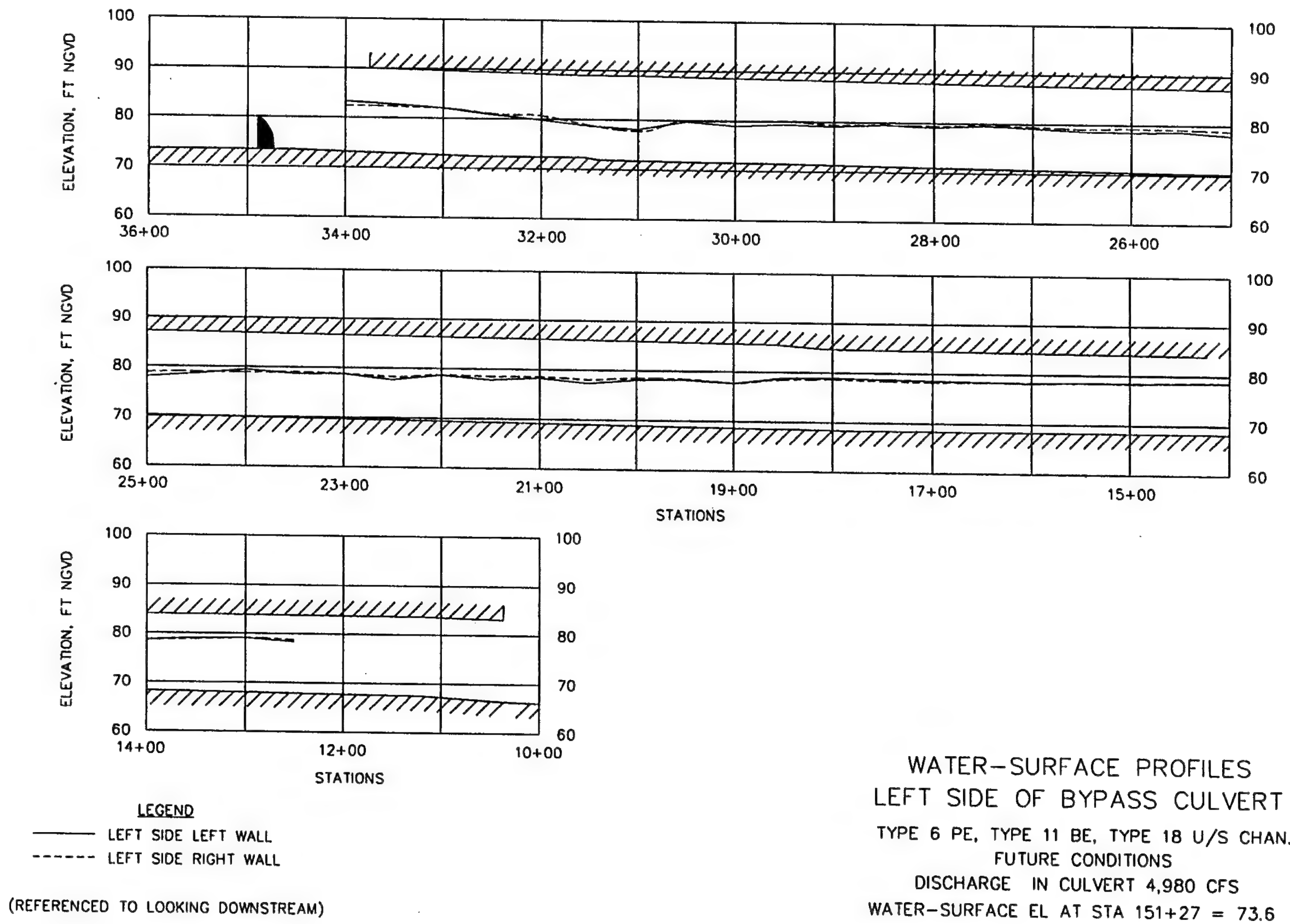
WATER-SURFACE ELEVATION AT STA 151+27 = 73.6




LEGEND

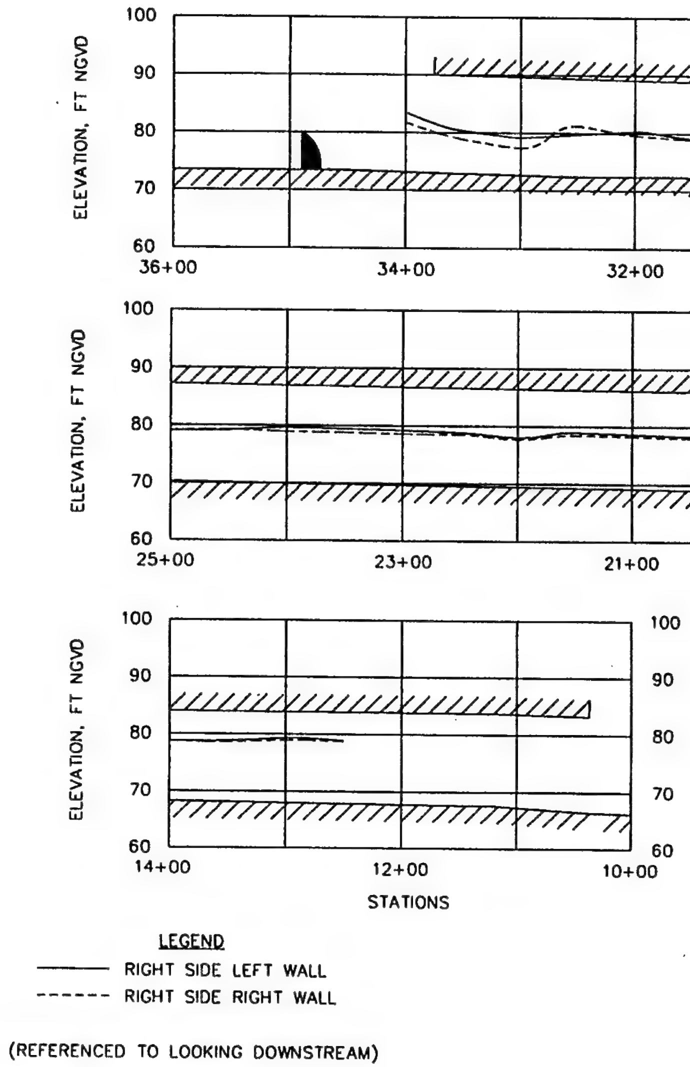
(REFERENCED TO LOOKING DOWNSTREAM)

STA 161+00 TO STA 151+00
TYPE 6 PE, TYPE 11 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS, DISCHARGE 9,100 CFS
WATER-SURFACE ELEVATION AT STA 151+27 = 73.6



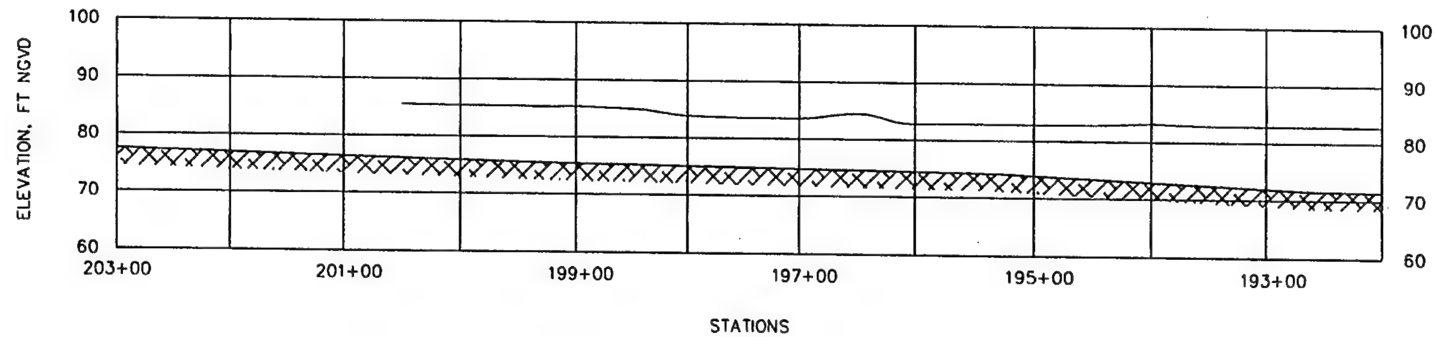

WATER-SURFACE PROFILES
LEFT SIDE OF BYPASS CULVERT

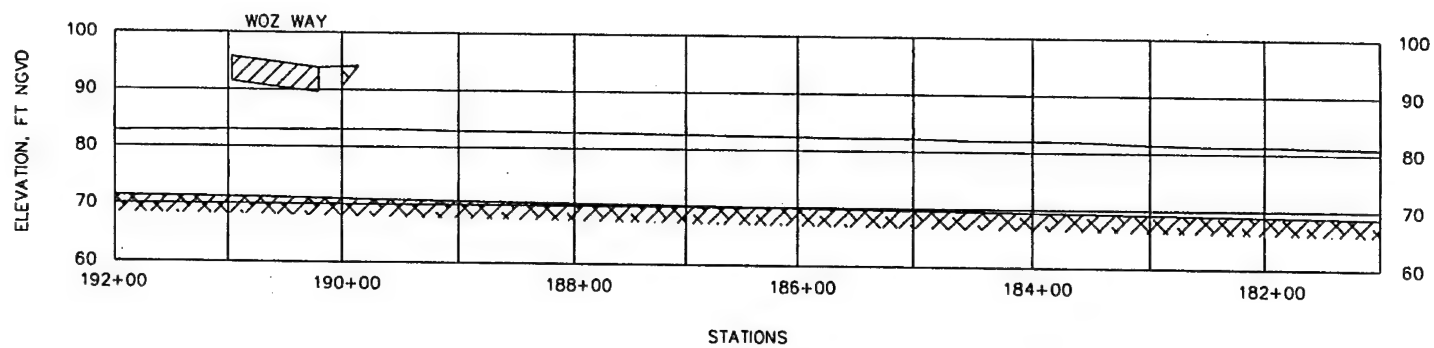
TYPE 6 PE, TYPE 11 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS
DISCHARGE IN CULVERT 4,980 CFS
WATER-SURFACE EL AT STA 151+27 = 73.6




WATER–SURFACE PROFILES
RIGHT SIDE OF BYPASS CULVERT

TYPE 6 PE, TYPE 11 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS
DISCHARGE IN CULVERT 4,980 CFS
WATER–SURFACE EL AT STA 151+27 = 73.6

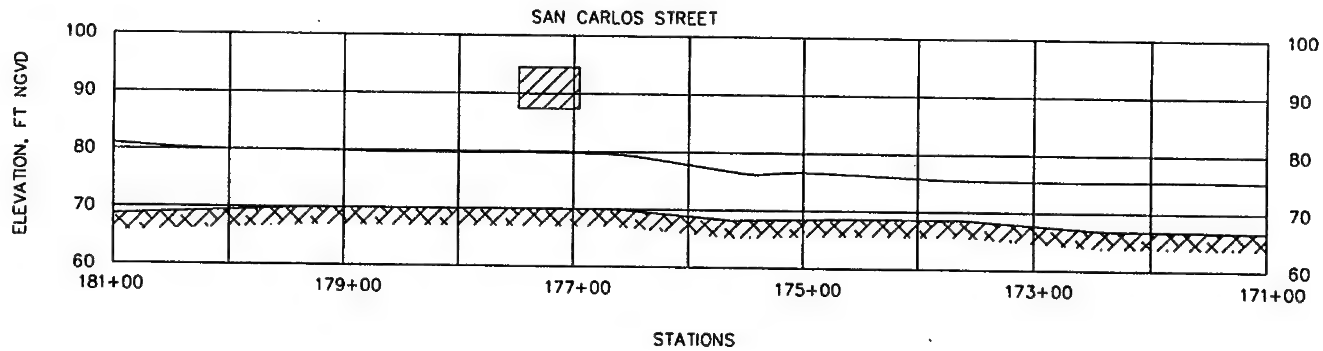


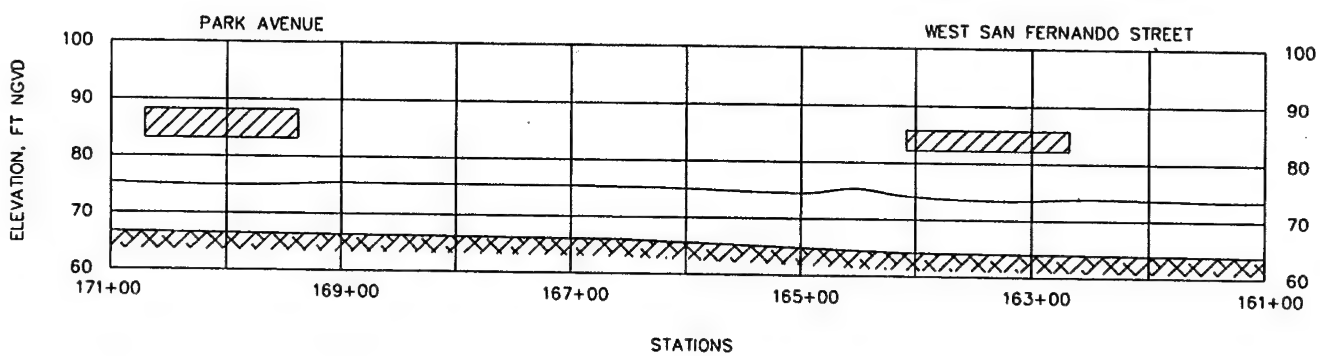




LEGEND

(REFERENCED TO LOOKING DOWNSTREAM)

STA 203+00 TO STA 181+00
TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS
DISCHARGE 6,500 CFS
WATER-SURFACE ELEVATION AT 151+27 = 71.9




LEGEND

(REFERENCED TO LOOKING DOWNSTREAM)

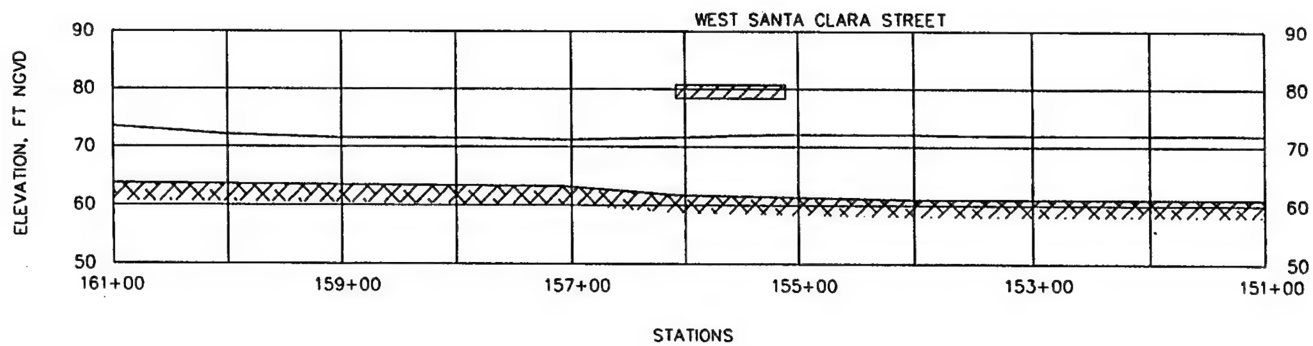
STA 181+00 TO 161+00

TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.

FUTURE CONDITIONS

DISCHARGE 6,500 CFS

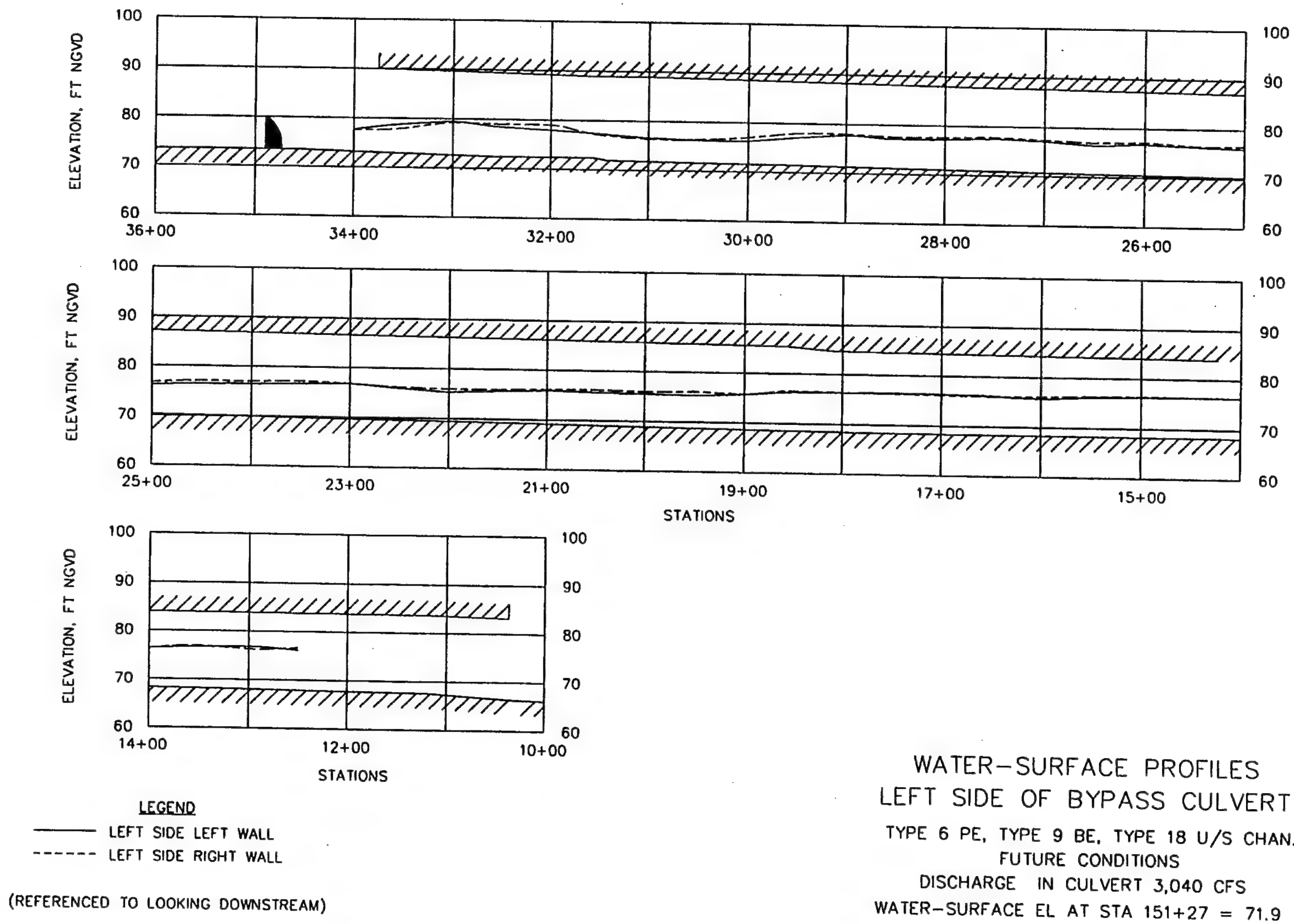
WATER-SURFACE ELEVATION AT STA 151+27 = 71.9




LEGEND

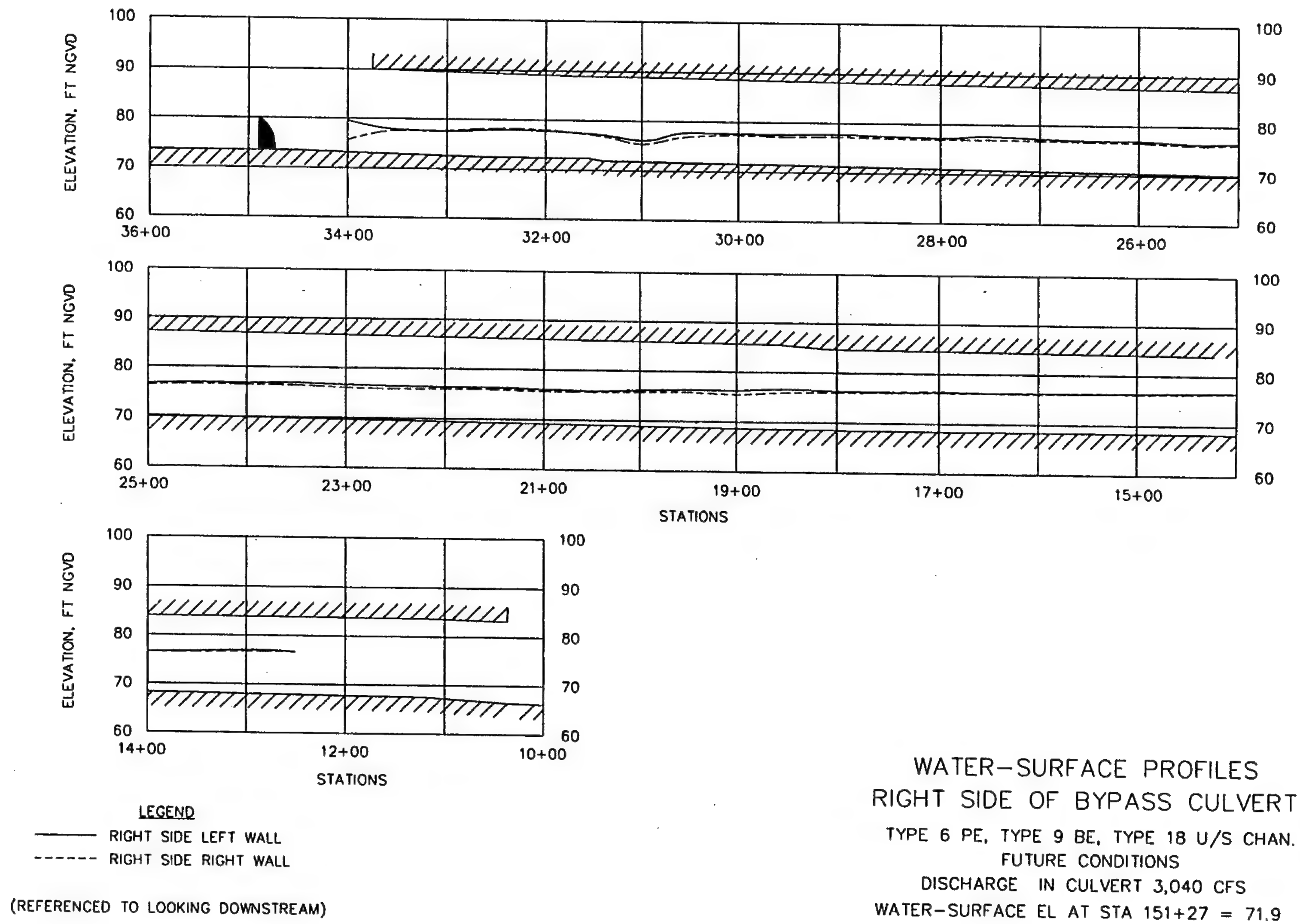
(REFERENCED TO LOOKING DOWNSTREAM)

STA 161+00 TO STA 151+00
TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS
DISCHARGE 6,500 CFS
WATER-SURFACE ELEVATION AT STA 151+27 = 71.9



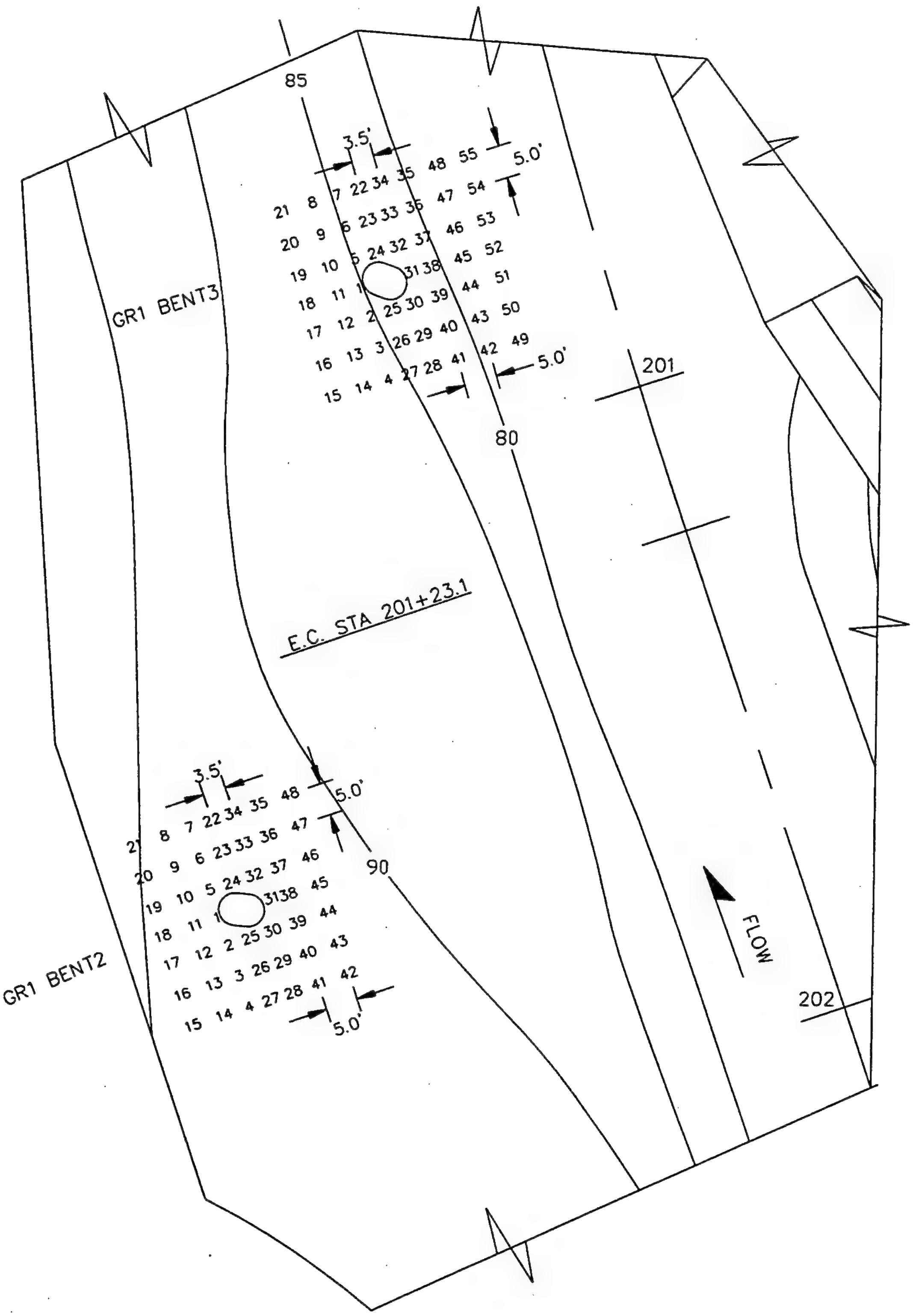

WATER–SURFACE PROFILES
LEFT SIDE OF BYPASS CULVERT

TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS
DISCHARGE IN CULVERT 3,040 CFS
WATER–SURFACE EL AT STA 151+27 = 71.9

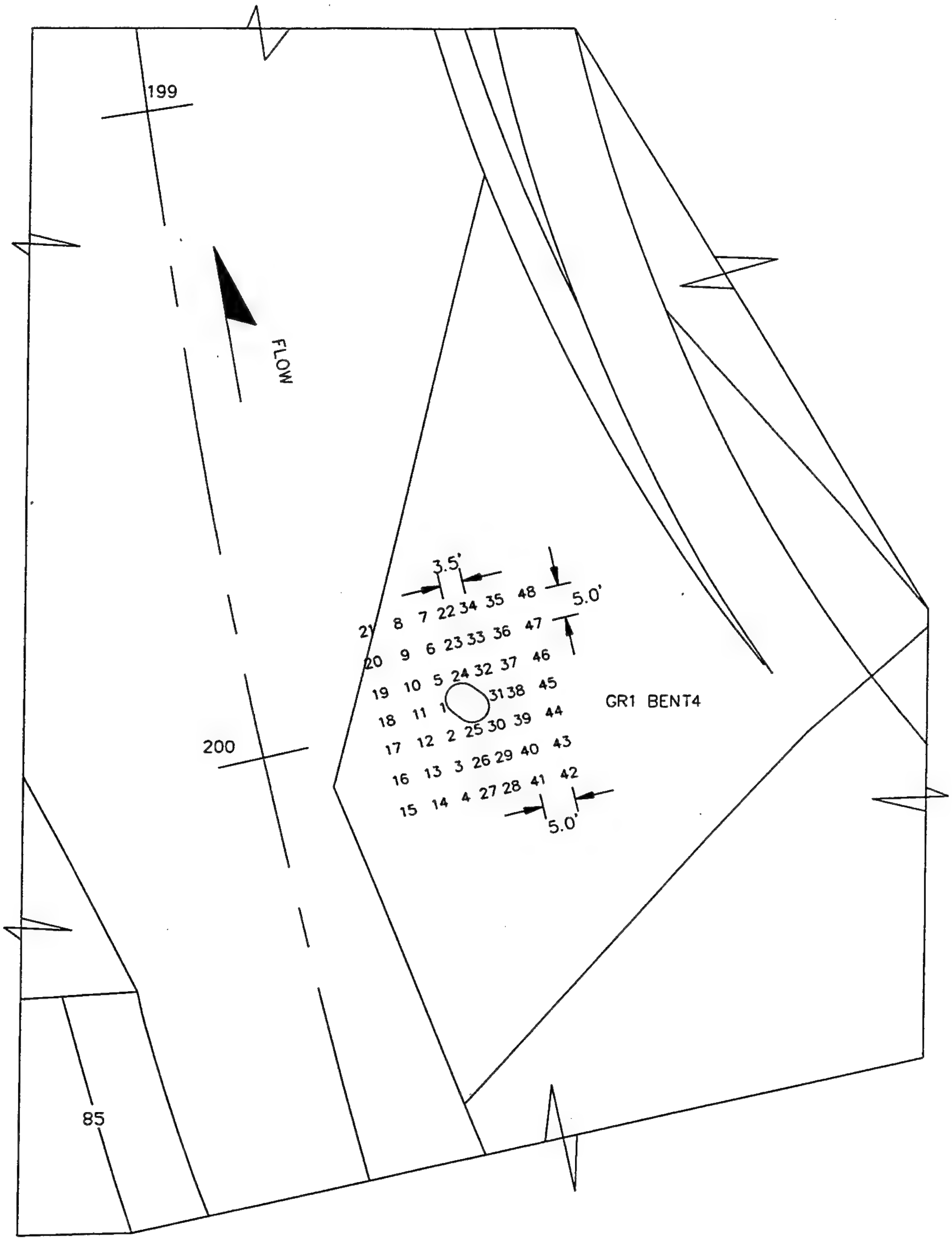



WATER–SURFACE PROFILES
RIGHT SIDE OF BYPASS CULVERT

TYPE 6 PE, TYPE 9 BE, TYPE 18 U/S CHAN.
FUTURE CONDITIONS
DISCHARGE IN CULVERT 3,040 CFS
WATER–SURFACE EL AT STA 151+27 = 71.9

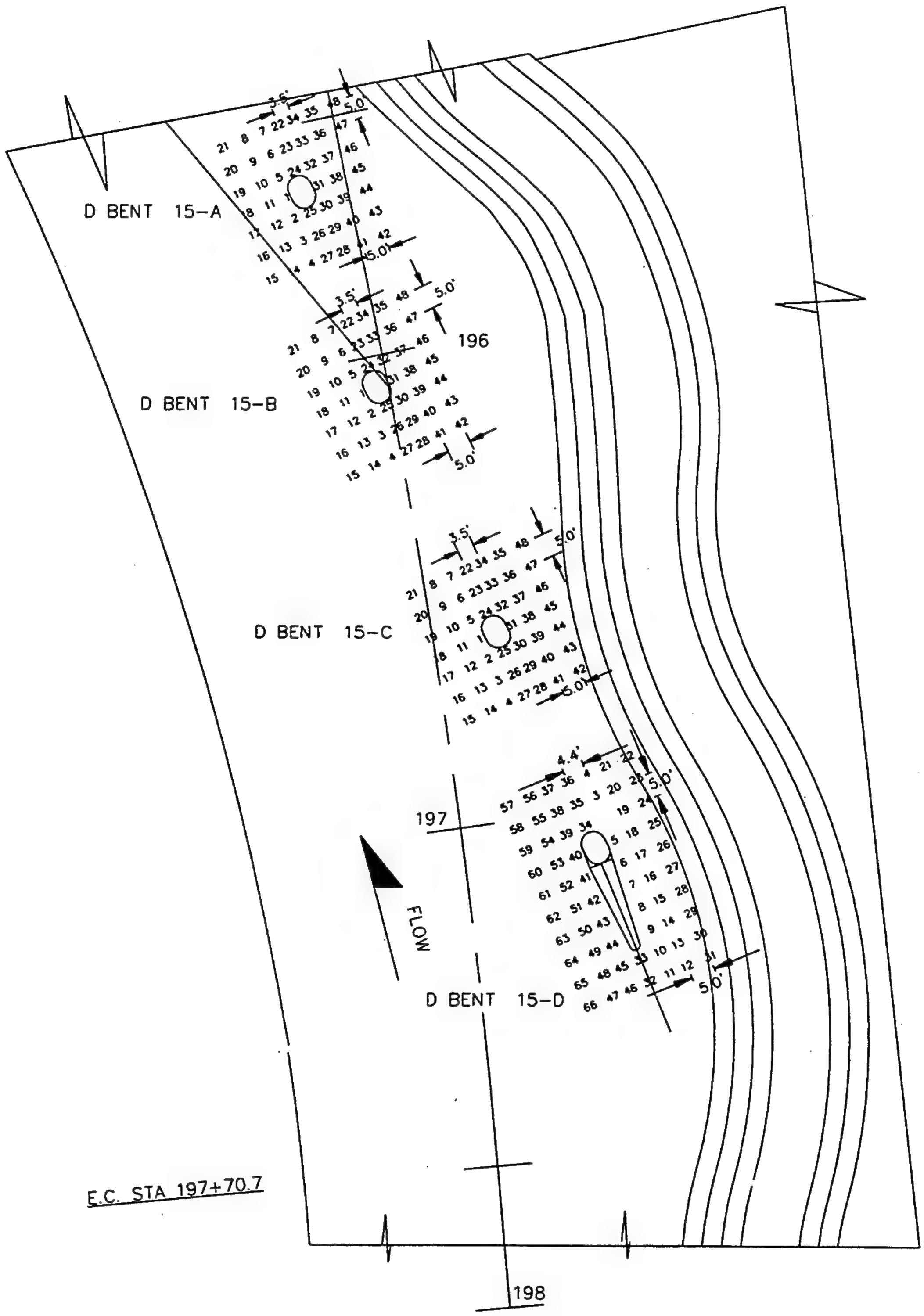



VELOCITY MEASUREMENT LOCATIONS
PIERS GR1 BENT 2 AND GR1 BENT 3

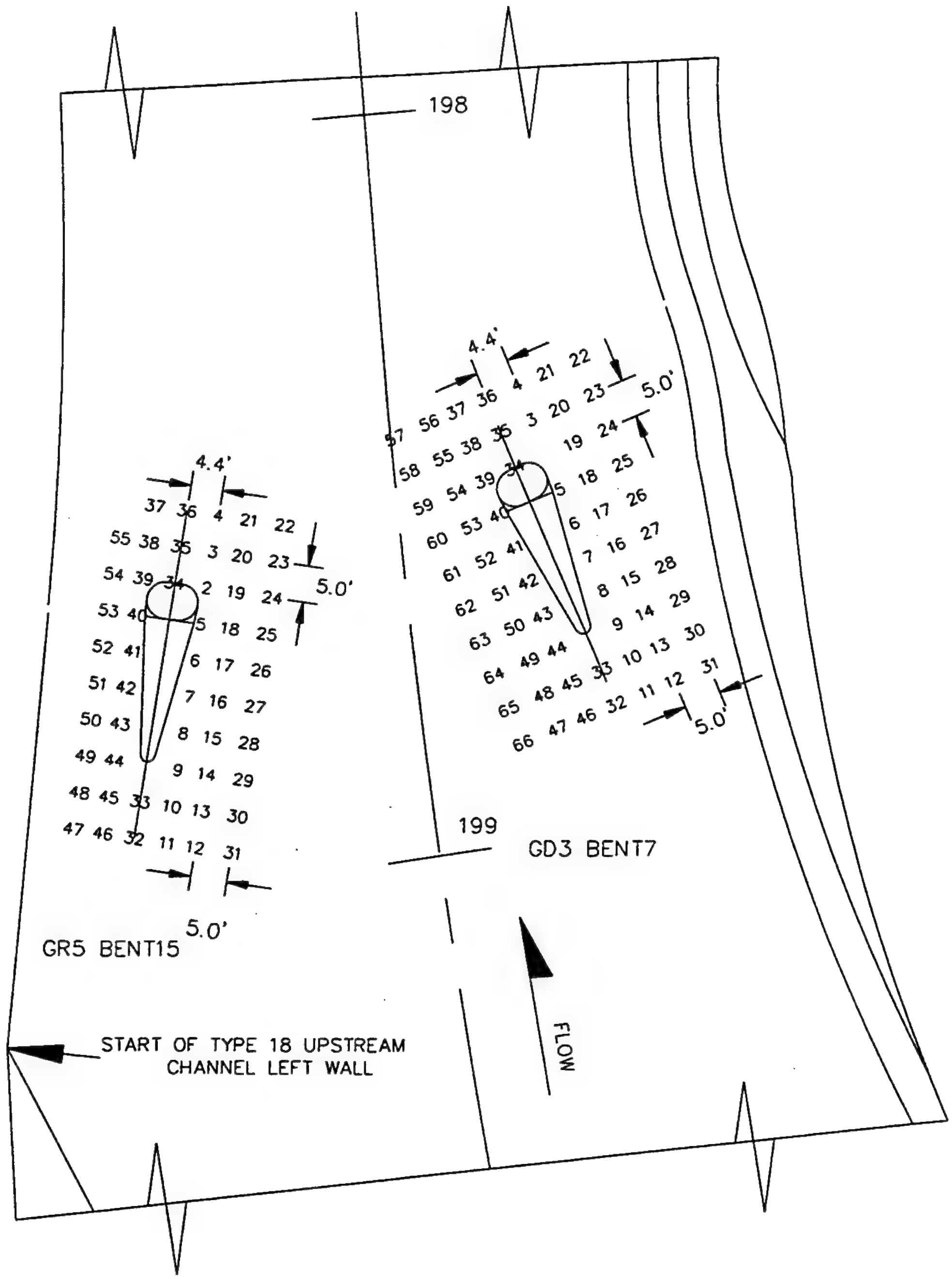



VELOCITY MEASUREMENT LOCATIONS

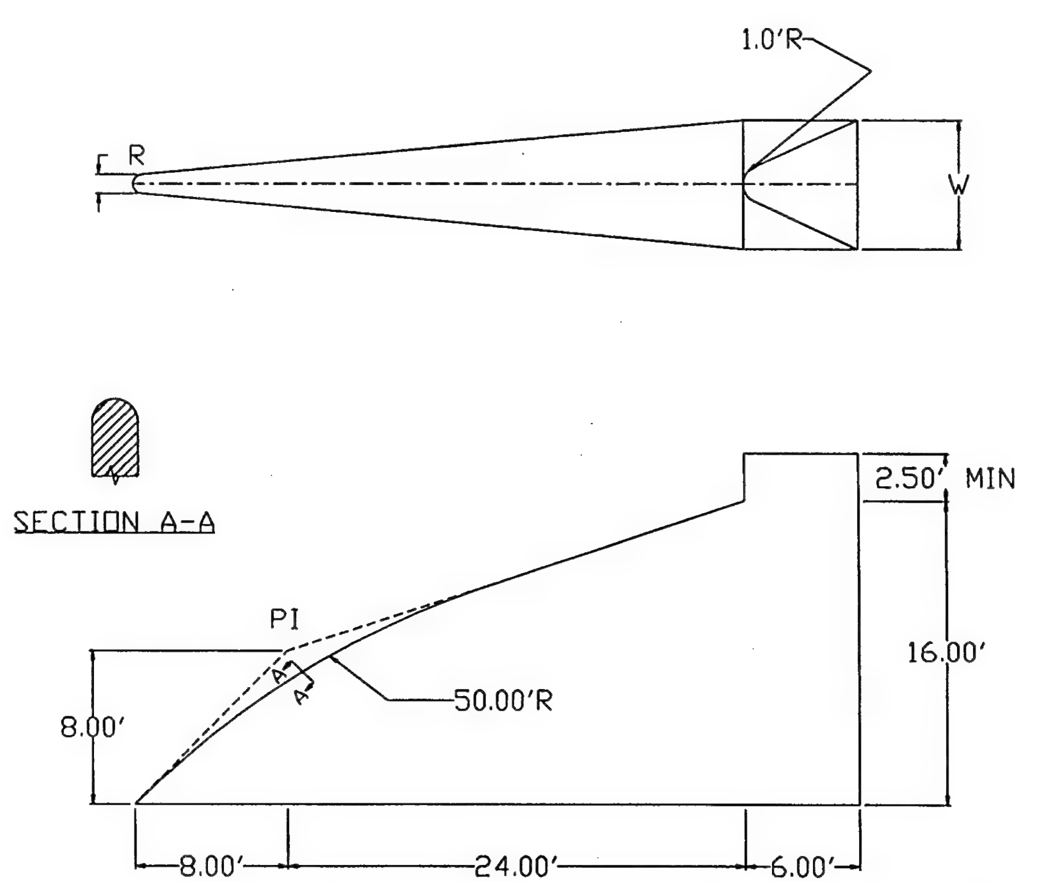
PIER GR1 BENT 4



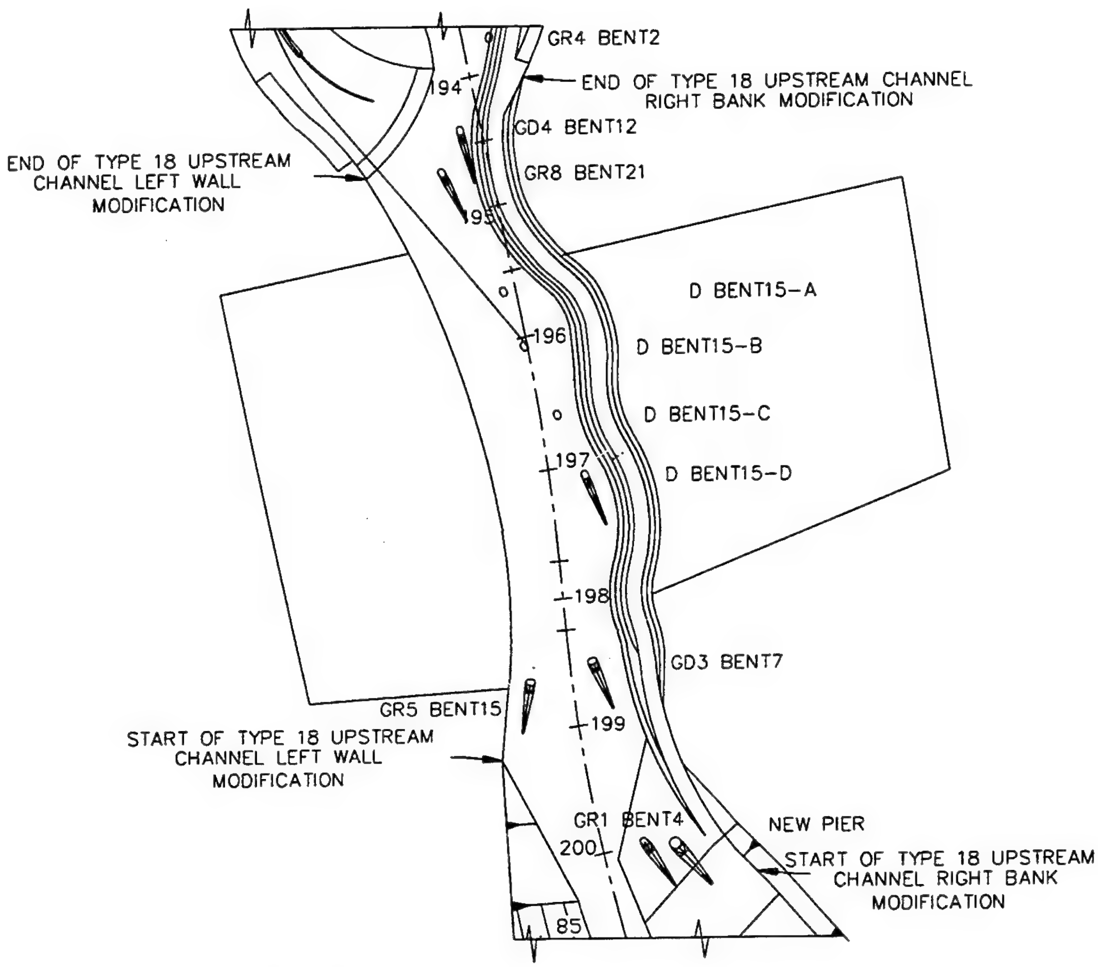

VELOCITY MEASUREMENT LOCATIONS
PIERS D BENT 15- A, -B, -C AND -D




VELOCITY MEASUREMENT LOCATIONS
PIERS GR5 BENT 15 AND GD3 BENT 7

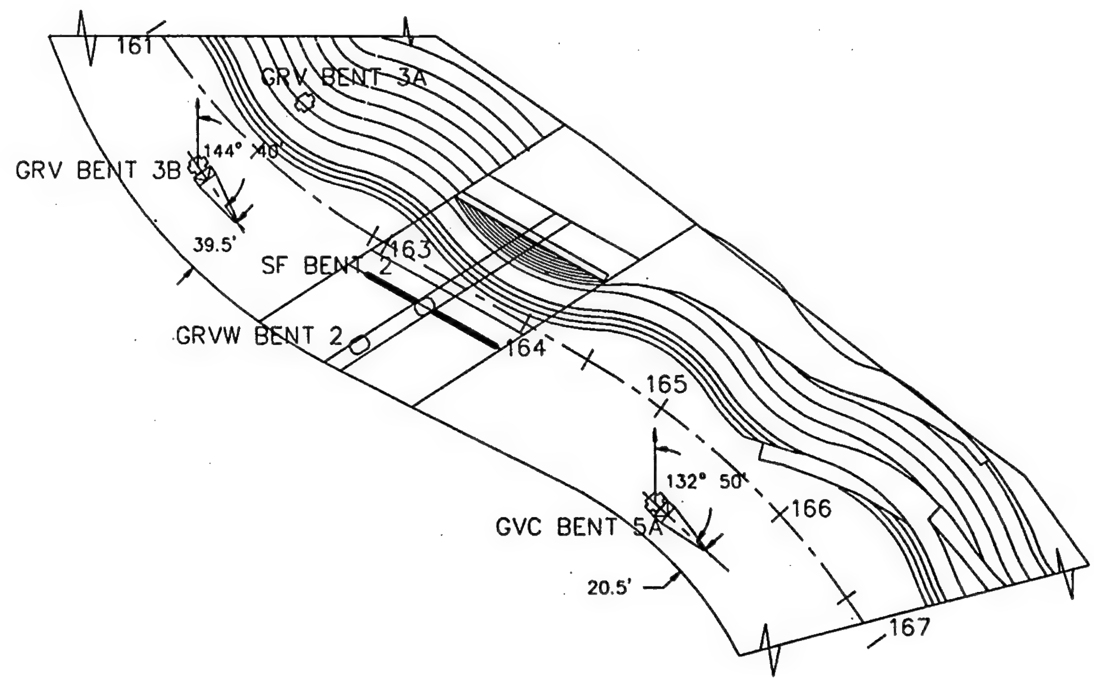



TYPICAL BRIDGE PIER
EXTENSION DESIGN



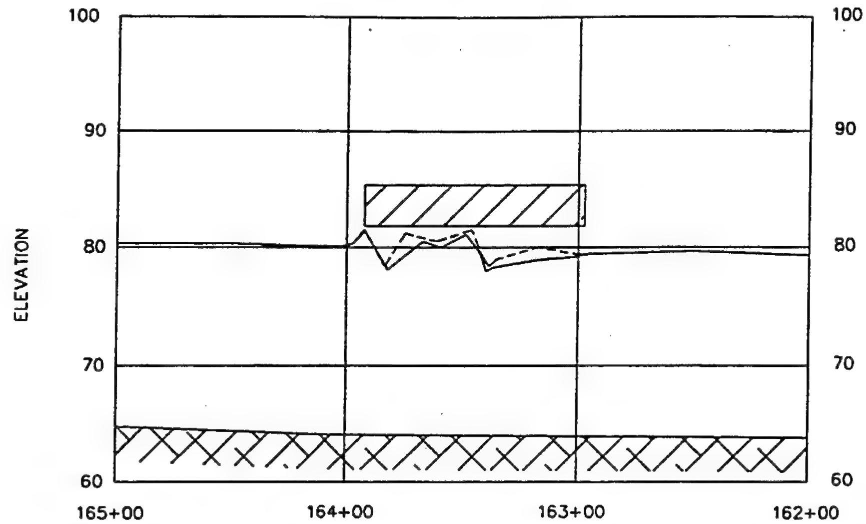

| PIER | PIER EXT. CL AZIMUTH |
|---|---|
| NEW PIER | 137D 59M |
| GR1 BENT 4 | 144D 47M |
| GR5 BENT 15 | 188D 21M |
| GD3 BENT 7 | 156D 48M |
| D BENT 15-D | 157D 1M |
| GR8 BENT 21 | 155D 30M |
| GD4 BENT 12 | 163D 53M |

UPSTREAM PIER EXTENSION LOCATIONS

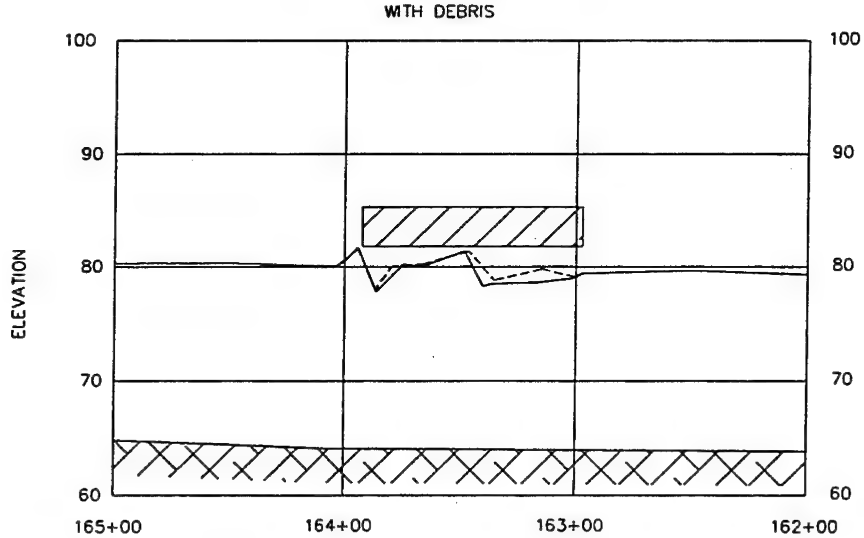



DOWNSTREAM PIER EXTENSION LOCATIONS

WEST SAN FERNANDO STREET
WITHOUT DEBRIS



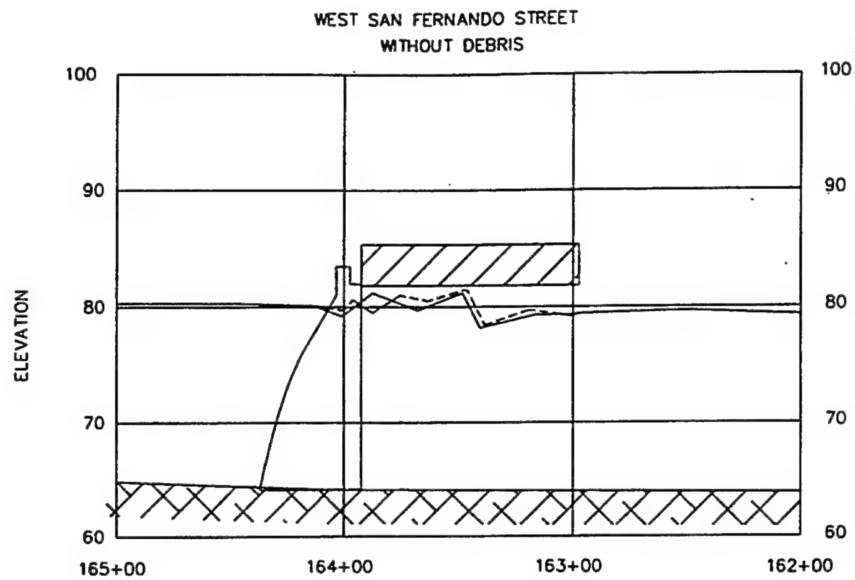

WEST SAN FERNANDO STREET
WITH DEBRIS

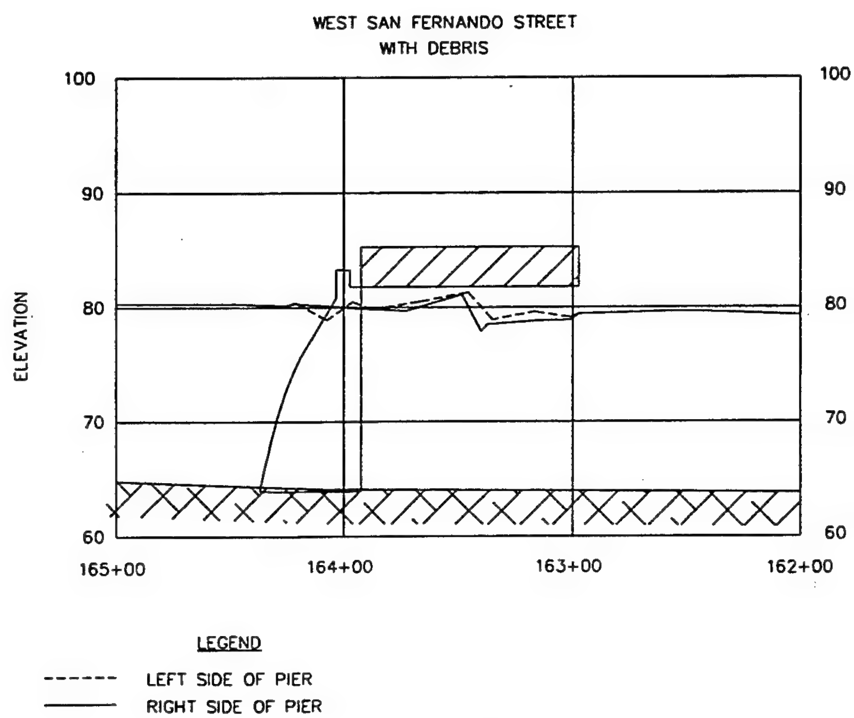



LEGEND

------ LEFT SIDE OF PIER
——— RIGHT SIDE OF PIER

WATER–SURFACE ELEVATIONS
SAN FERNANDO ST. BRIDGE
ORIGINAL DESIGN PIER
DISCHARGE 14,600 CFS
WATER–SURFACE ELEVATION AT STA 151+27 = 77.0



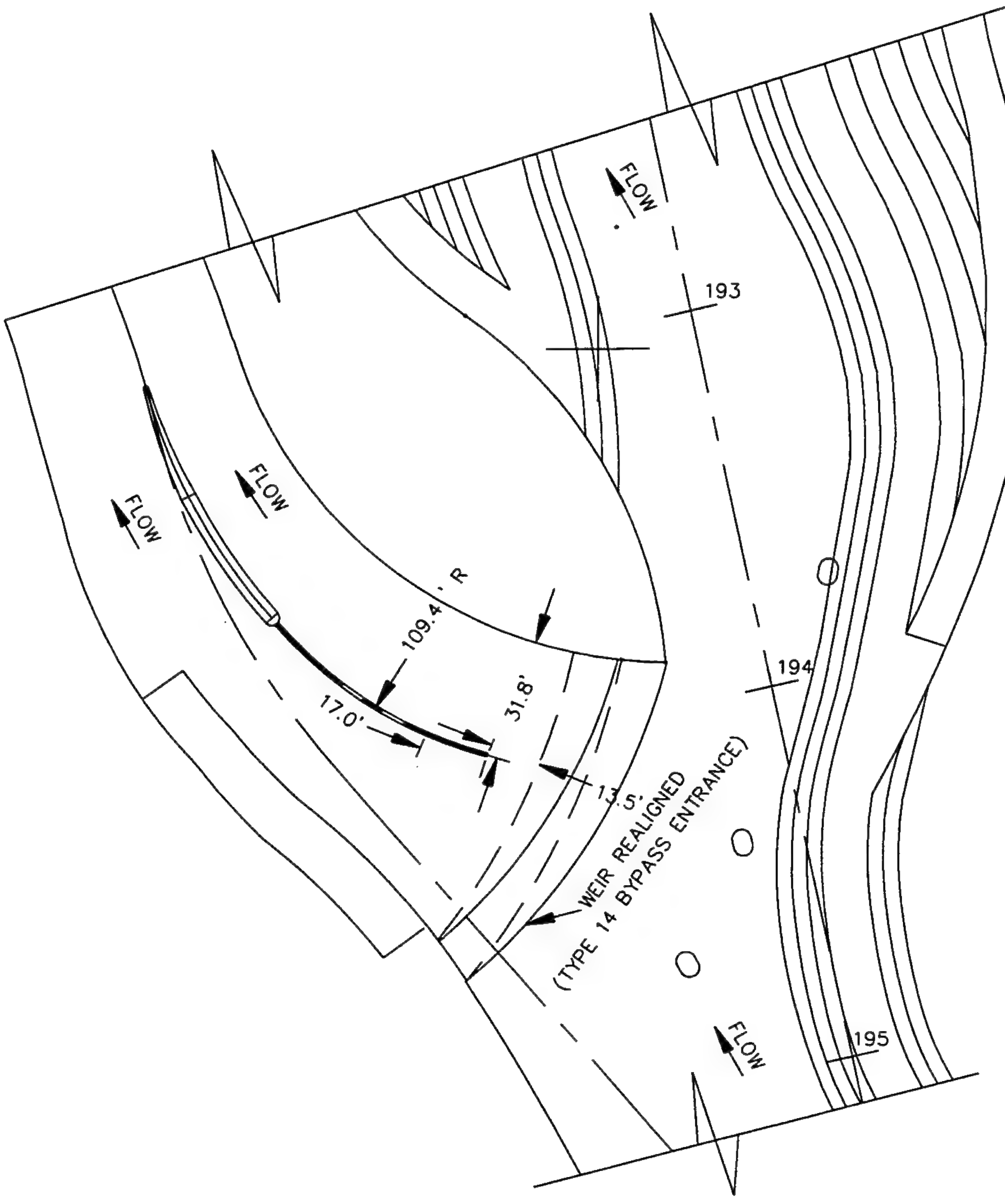

WATER–SURFACE ELEVATIONS

SAN FERNANDO ST. BRIDGE

WITH PIER EXTENSION

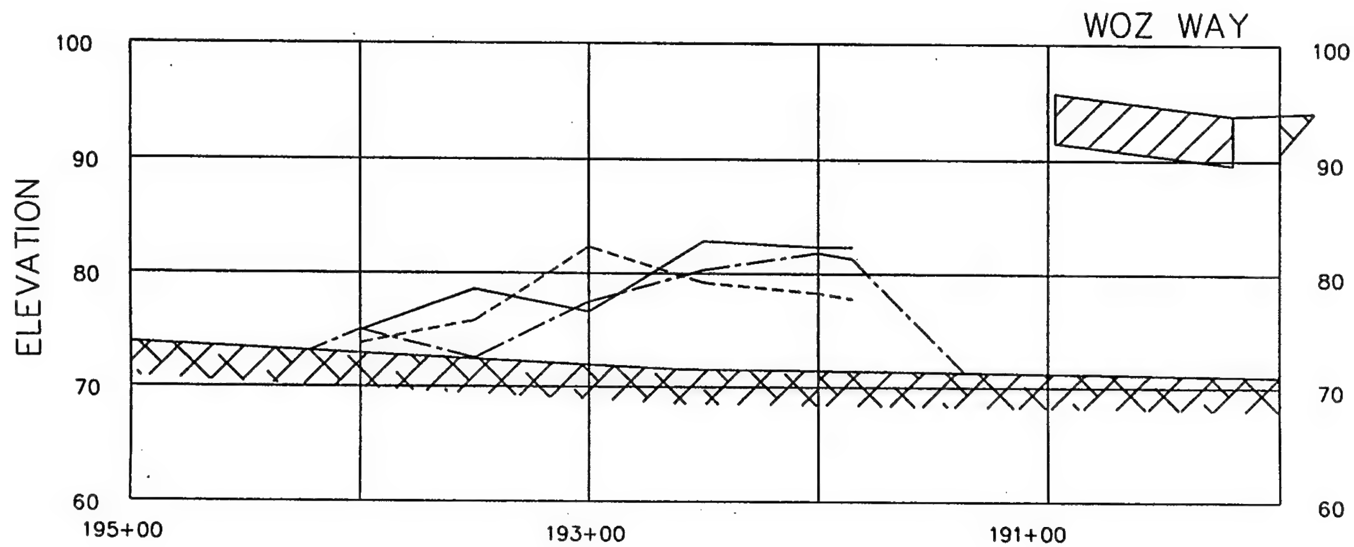
DISCHARGE 14,600 CFS

WATER–SURFACE ELEVATION AT STA 151+27 = 77.0




NOTE: WALL IS 1 FT THICK AND 14FT HIGH
TYPE 14 BYPASS ENTRANCE INCLUDES WALL WITH
1V ON 1H SLOPE AT UPSTREAM END

TYPES 14 BYPASS ENTRANCE

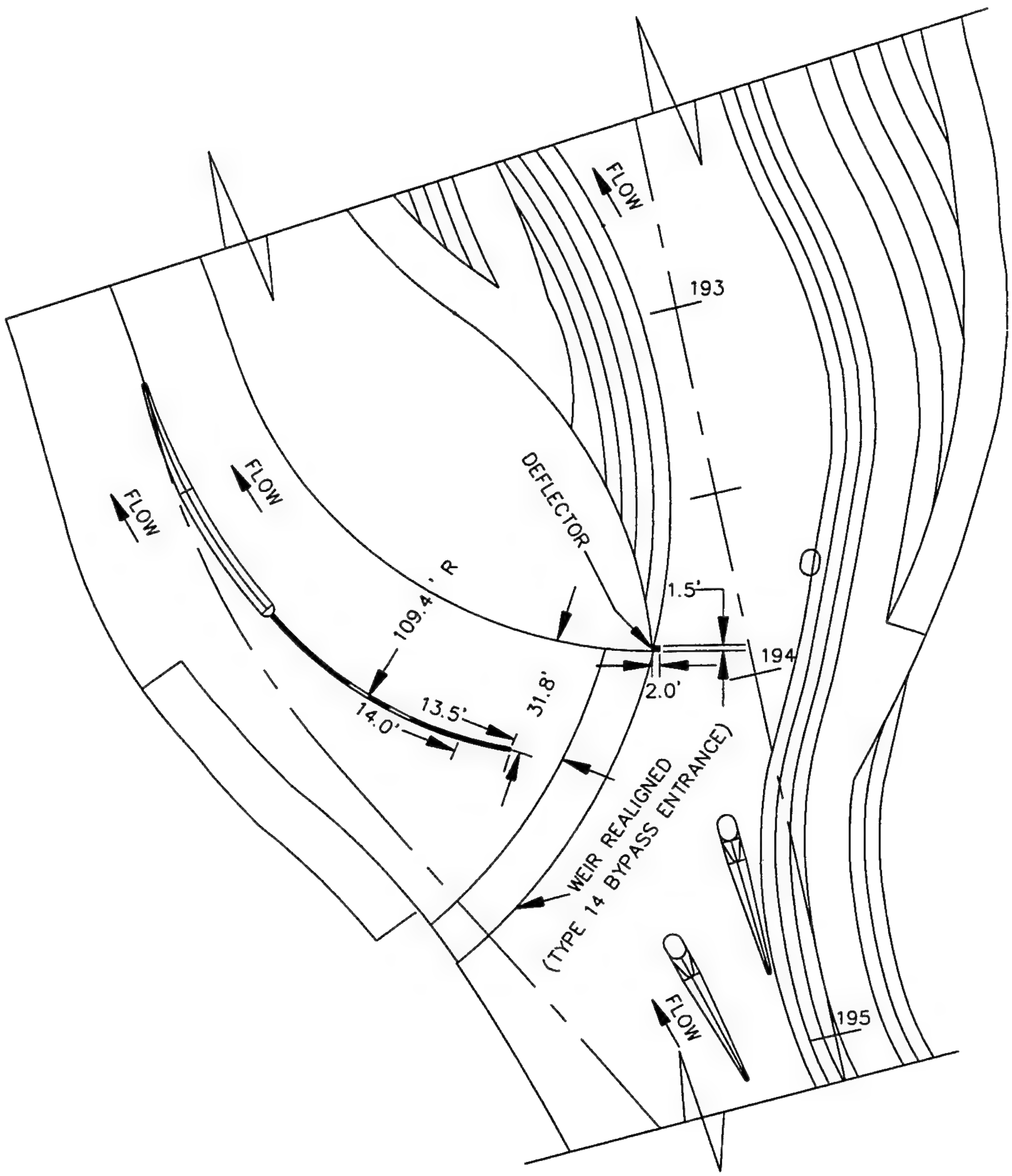



LEGEND

— · — CENTER OF CHANNEL
- - - - LEFT SIDE OF CHANNEL
——— RIGHT SIDE OF CHANNEL

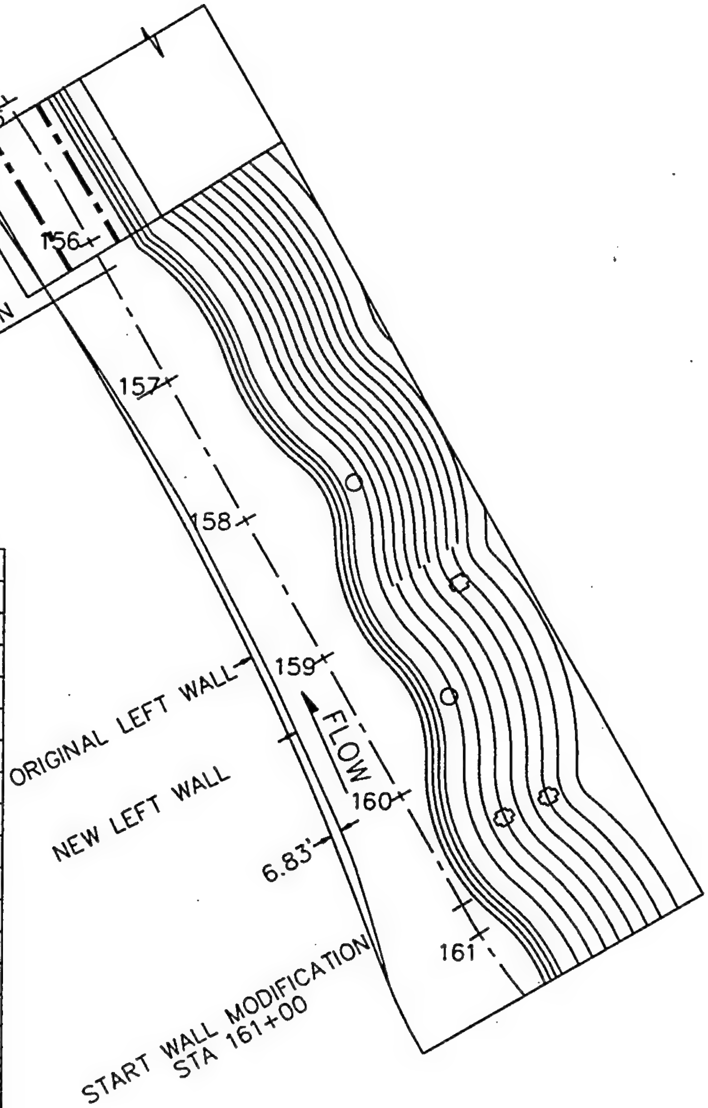
(REFERENCED TO LOOKING DOWNSTREAM)

SEDIMENT PROFILES
TYPE 14 BE, TYPE 18 U/S CHAN.
DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT 151+27 = 77.0




NOTE: DIVIDER WALL IS 1 FT THICK AND 14 FT HIGH
TYPE 15 BYPASS ENTRANCE INCLUDES WALL WITH
1V ON 1H SLOPE AT UPSTREAM END AND DEFLECTOR
WALL ON RIVERSIDE AT BYPASS ENTRANCE

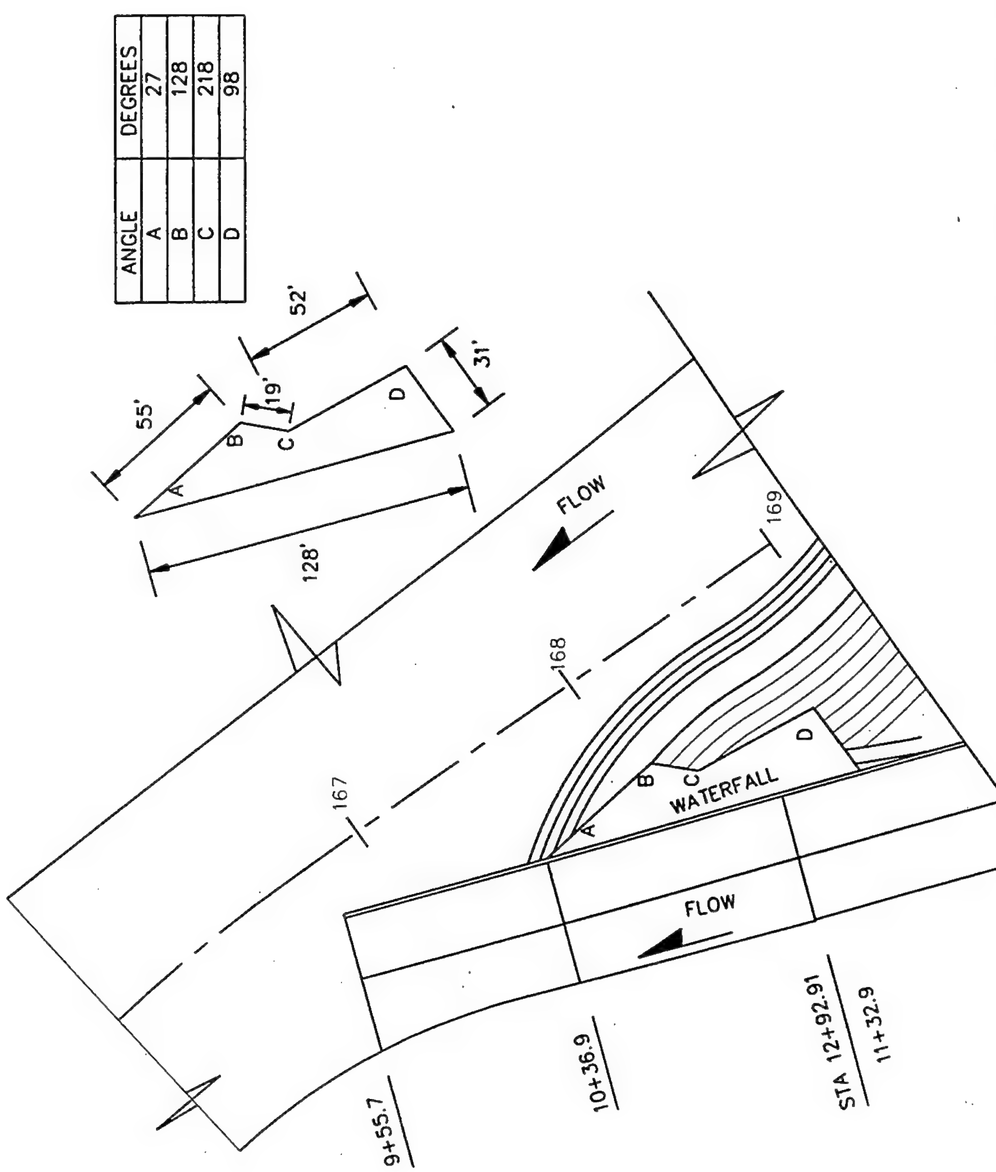
TYPES 15 BYPASS ENTRANCE




| STA | OFFSET |
|---|---|
| 161+00 | 0.00 |
| 160+75 | 3.30 |
| 160+50 | 5.43 |
| 160+25 | 6.93 |
| 160+00 | 6.83 |
| 159+75 | 6.09 |
| 159+50 | 5.60 |
| 159+25 | 5.38 |
| 159+00 | 5.37 |
| 158+75 | 5.26 |
| 158+50 | 4.96 |
| 158+25 | 4.94 |
| 158+00 | 5.20 |
| 157+75 | 5.24 |
| 157+50 | 4.56 |
| 157+25 | 3.76 |
| 157+00 | 2.90 |
| 156+75 | 2.04 |
| 156+50 | 1.12 |
| 156+21.33 | 0.00 |

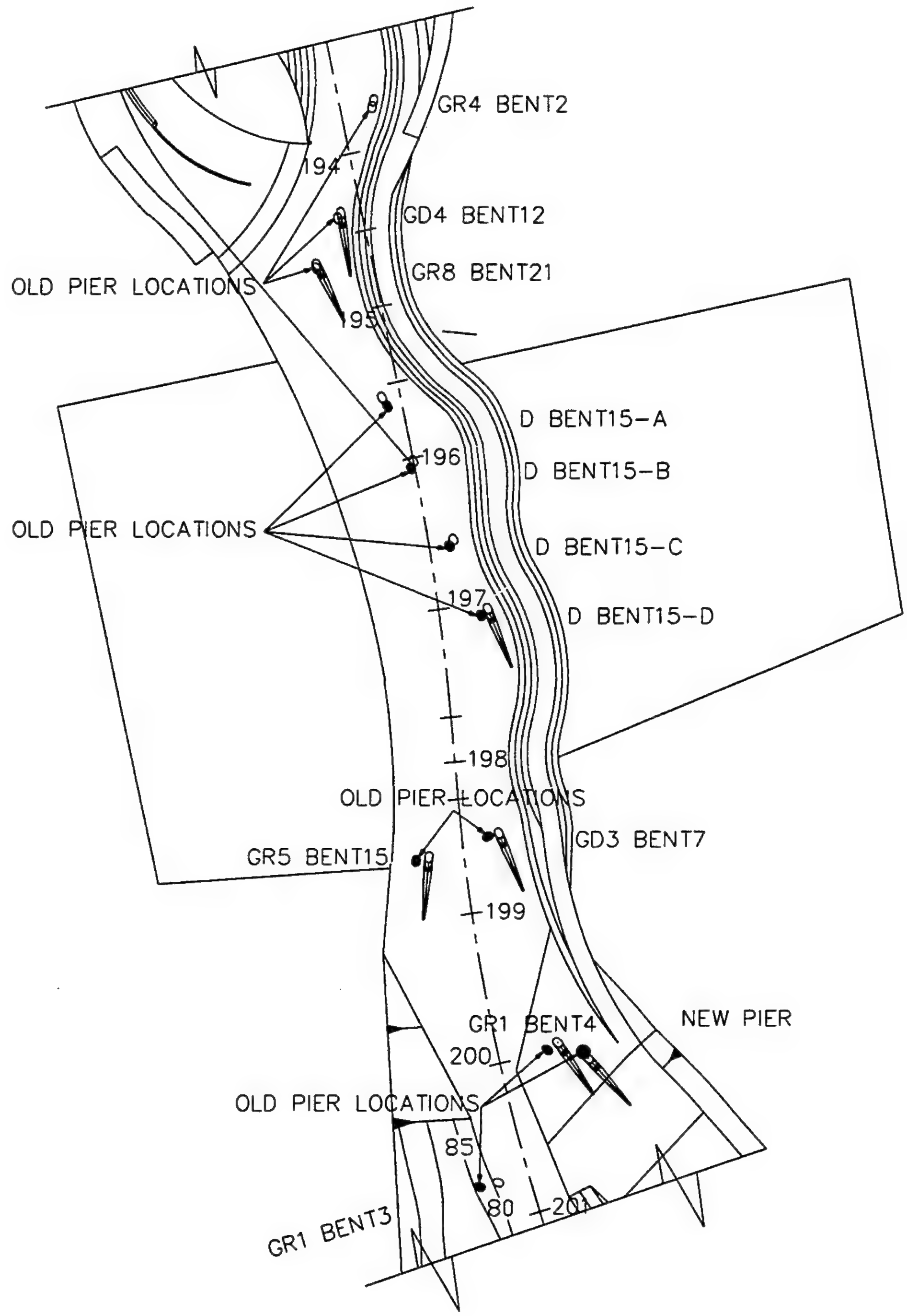
NOTE: OFFSET DIRECTION IS NORMAL TO CENTER LINE FROM ORIGINAL LEFT WALL IN FT

LEFT WALL MODIFICATION
UPSTREAM FROM SANTA CLARA ST. BRIDGE

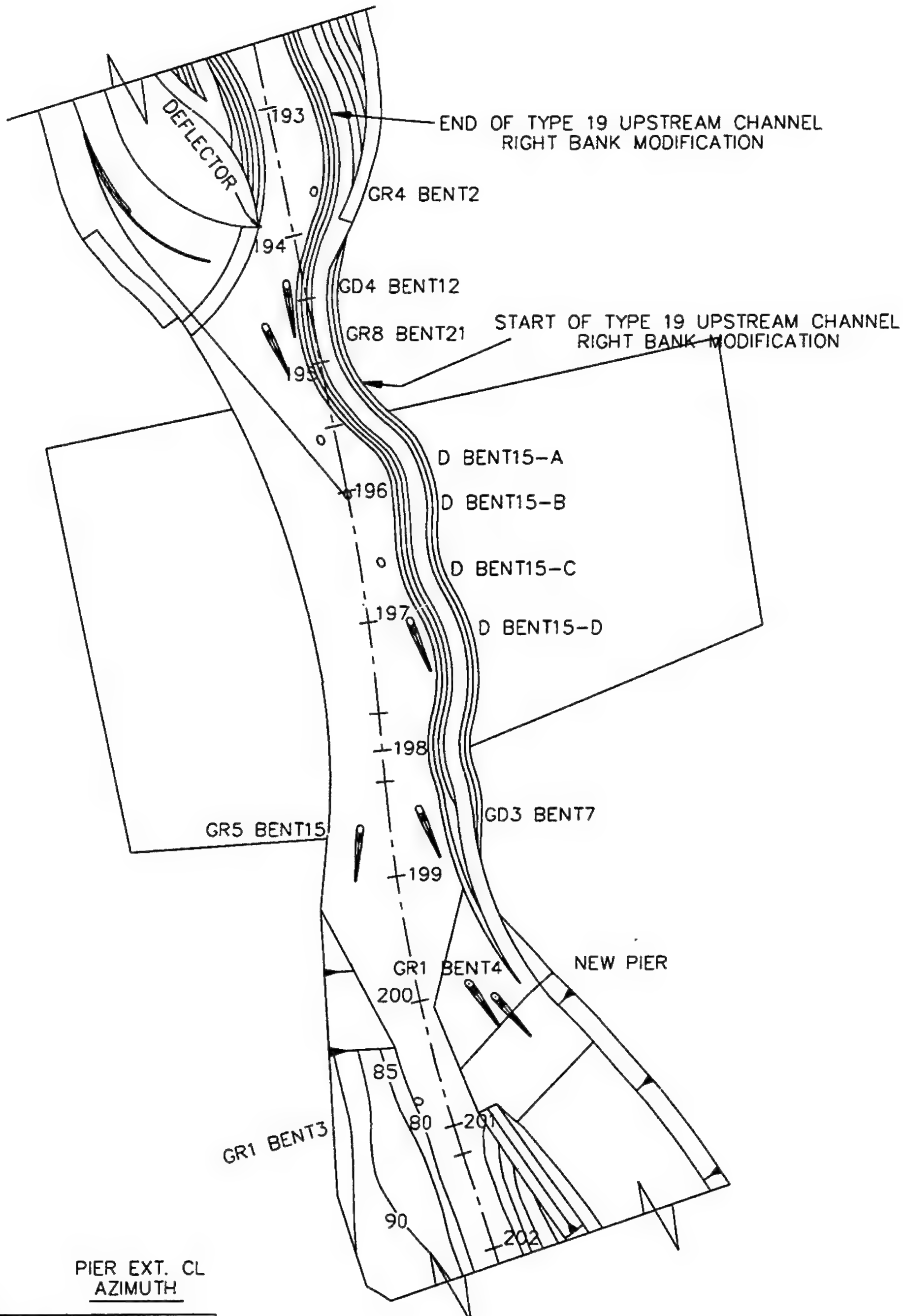



PLAN VIEW OF WATERFALL

Plate 90

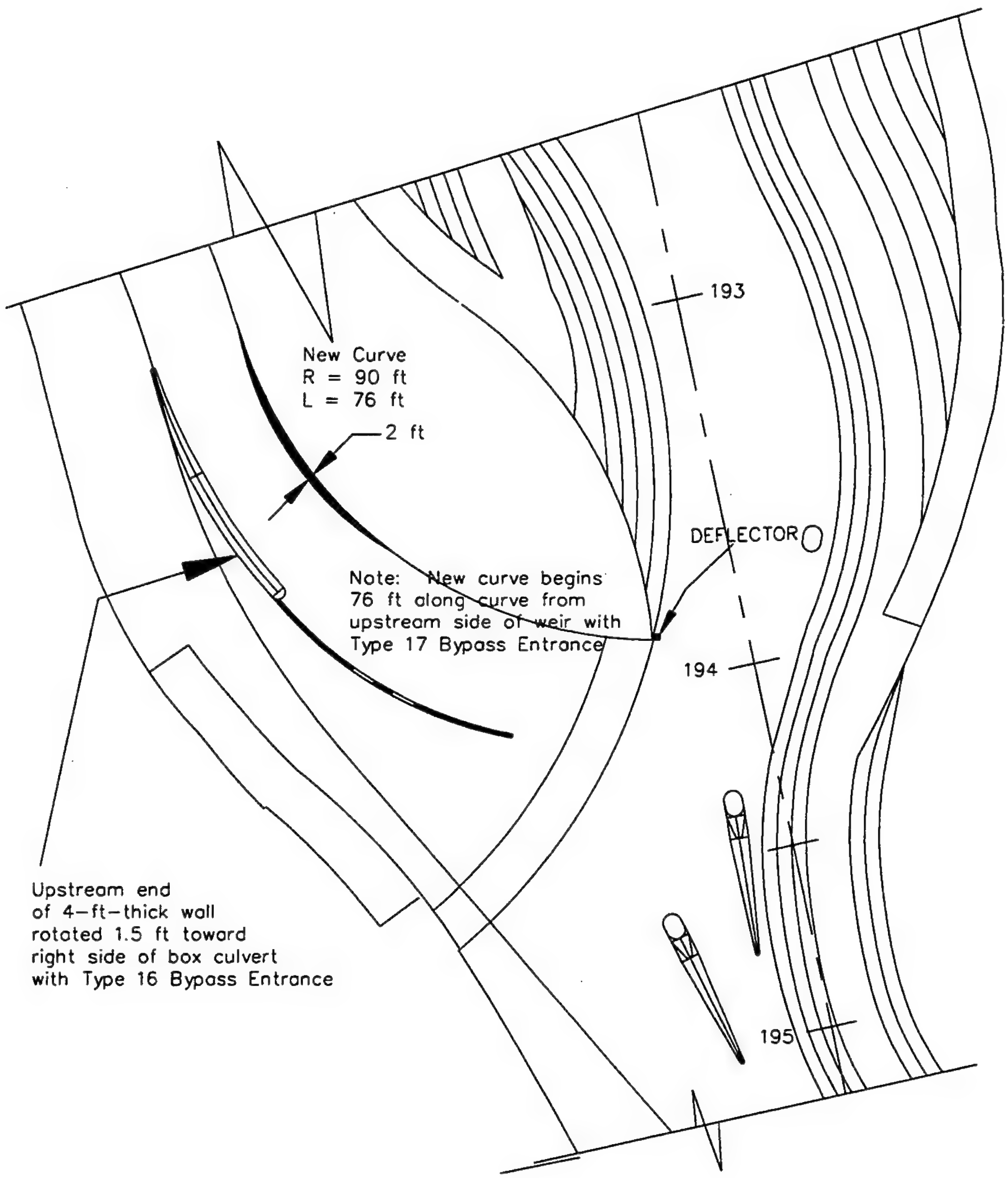



NEW PIER LOCATIONS
COMPARED TO OLD LOCATIONS

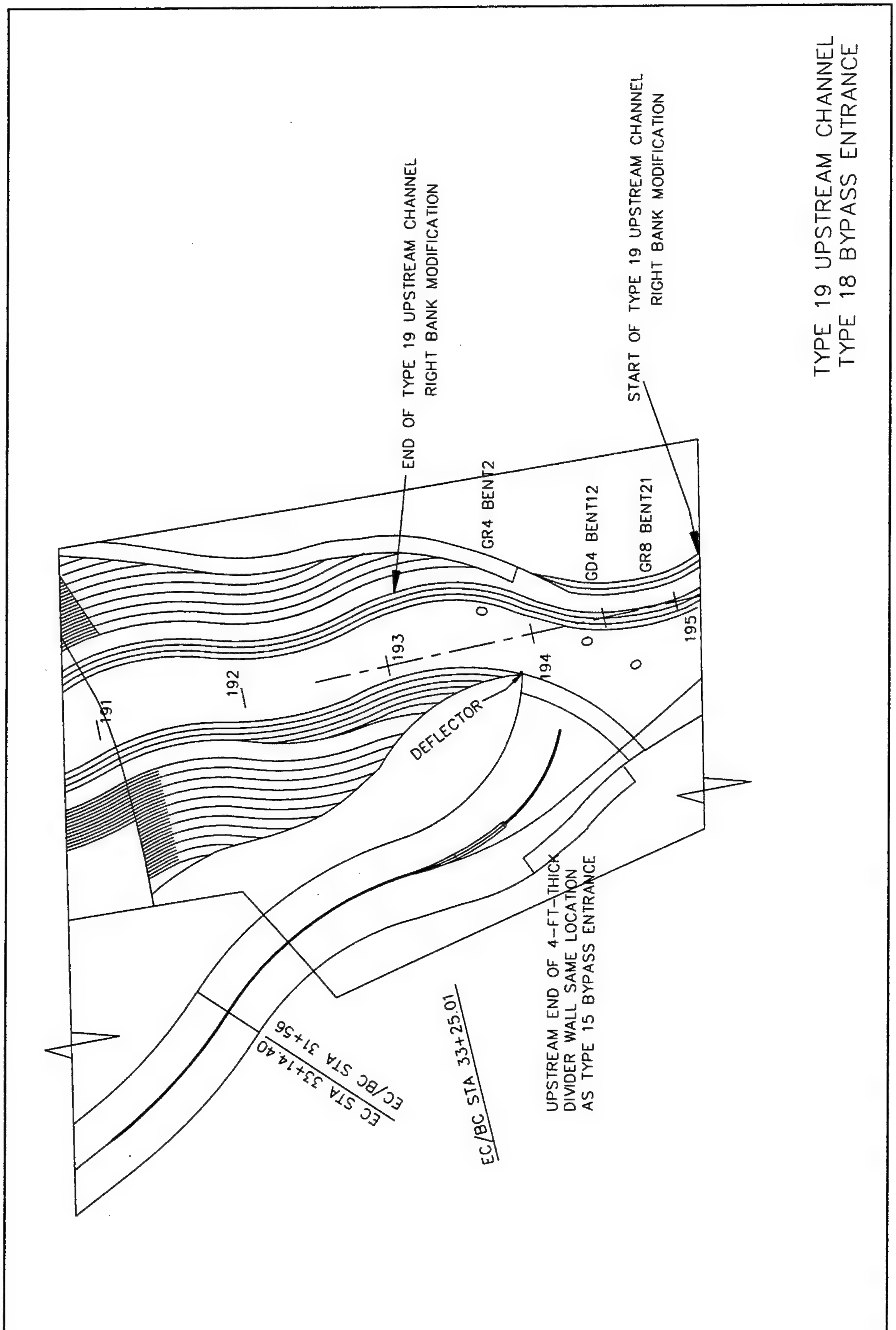



| PIER | PIER EXT. CL AZIMUTH |
|---|---|
| NEW PIER | 137D 59M |
| GR1 BENT 4 | 144D 47M |
| GR5 BENT 15 | 184D 32M |
| GD3 BENT 7 | 156D 48M |
| D BENT 15-D | 157D 1 M |
| GR8 BENT 21 | 152D 57M |
| GD4 BENT 12 | 170D 31M |

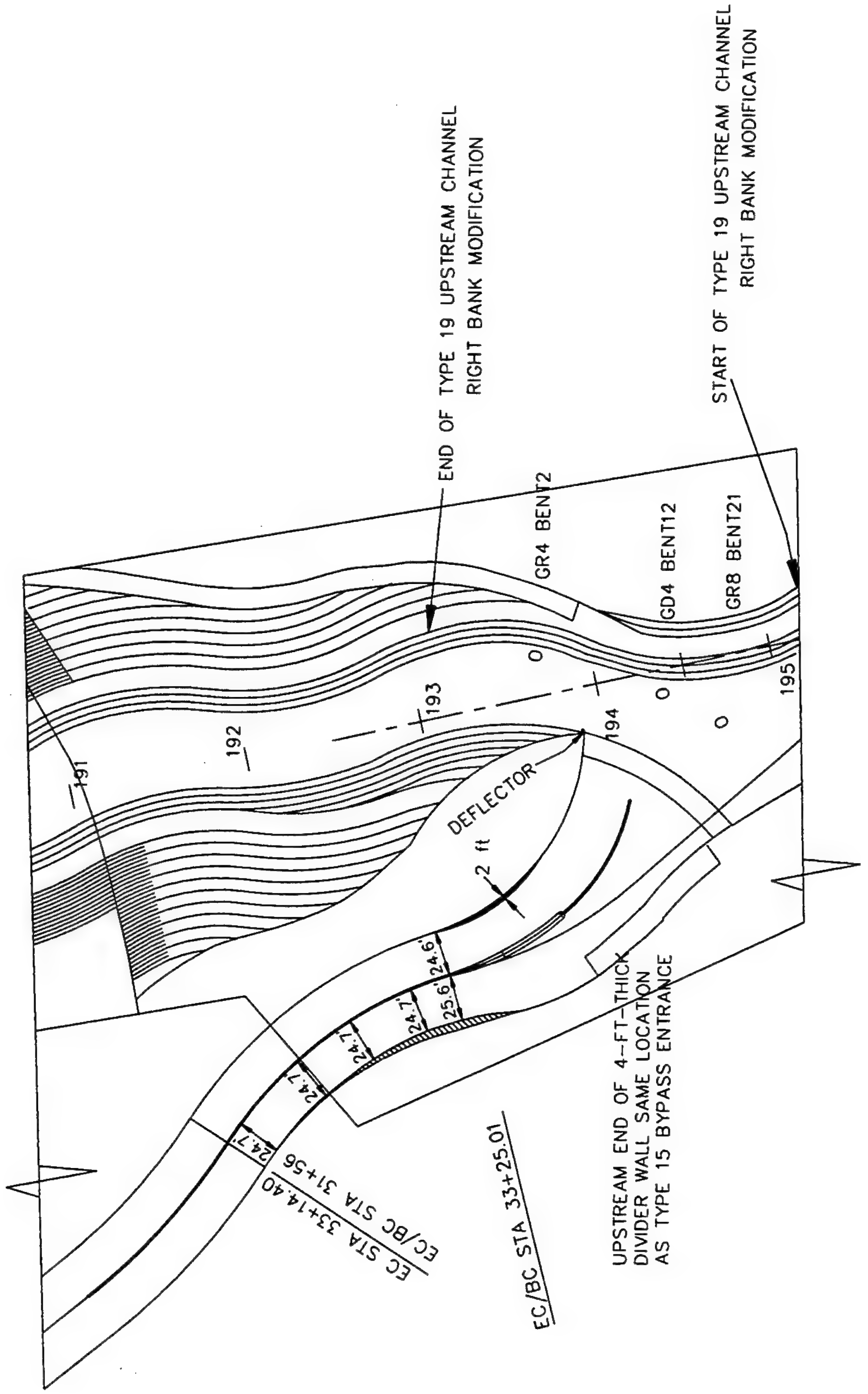
TYPE 8 PIER EXTENSIONS
TYPE 16 BYPASS ENTRANCE
TYPE 19 UPSTREAM CHANNEL



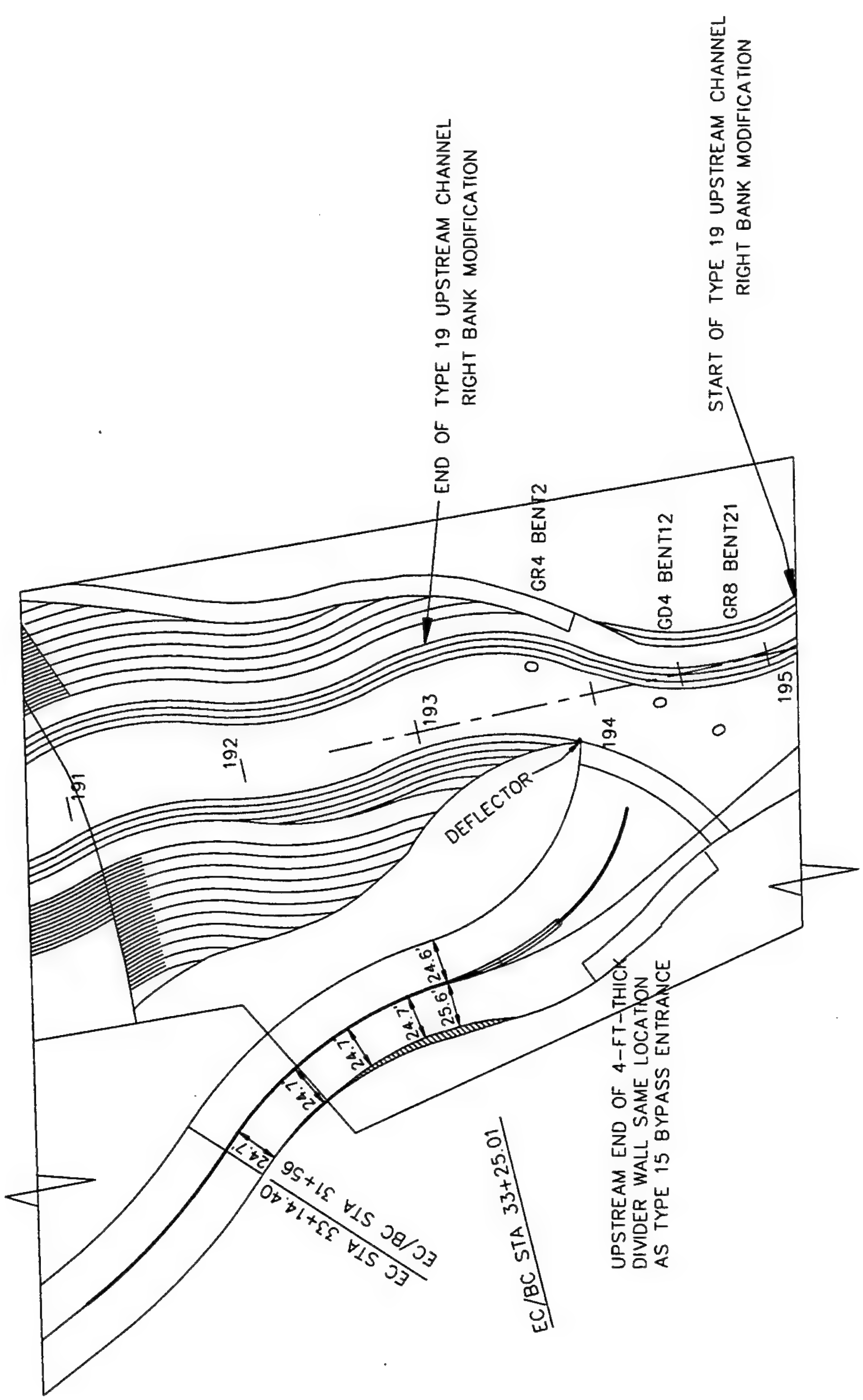

TYPES 16 AND 17 BYPASS ENTRANCES



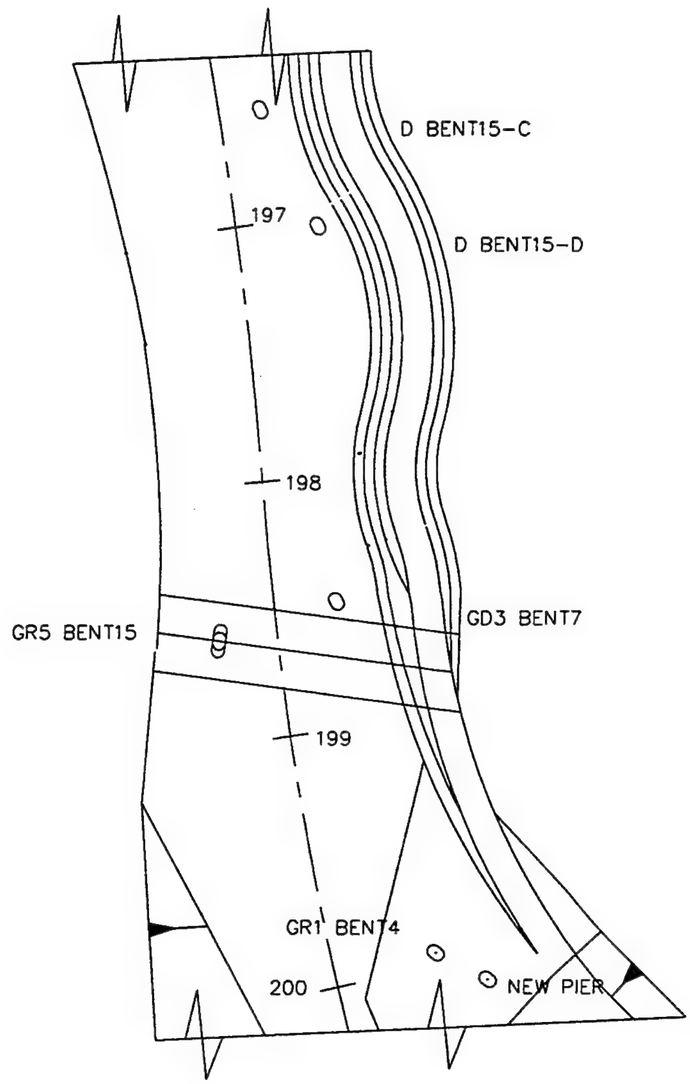

TYPE 19 UPSTREAM CHANNEL
TYPE 18 BYPASS ENTRANCE



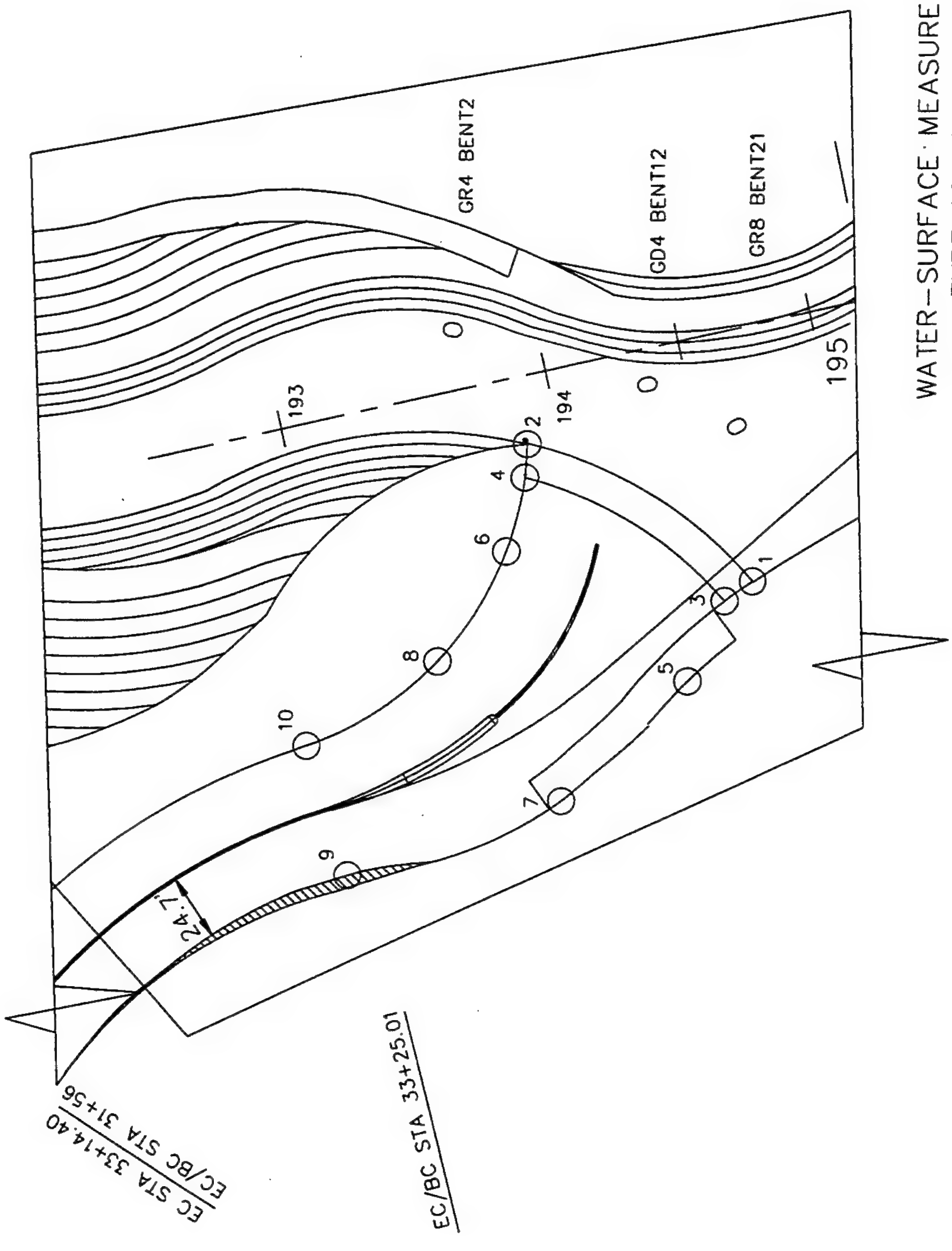

TYPE 19 UPSTREAM CHANNEL
TYPE 19 BYPASS ENTRANCE



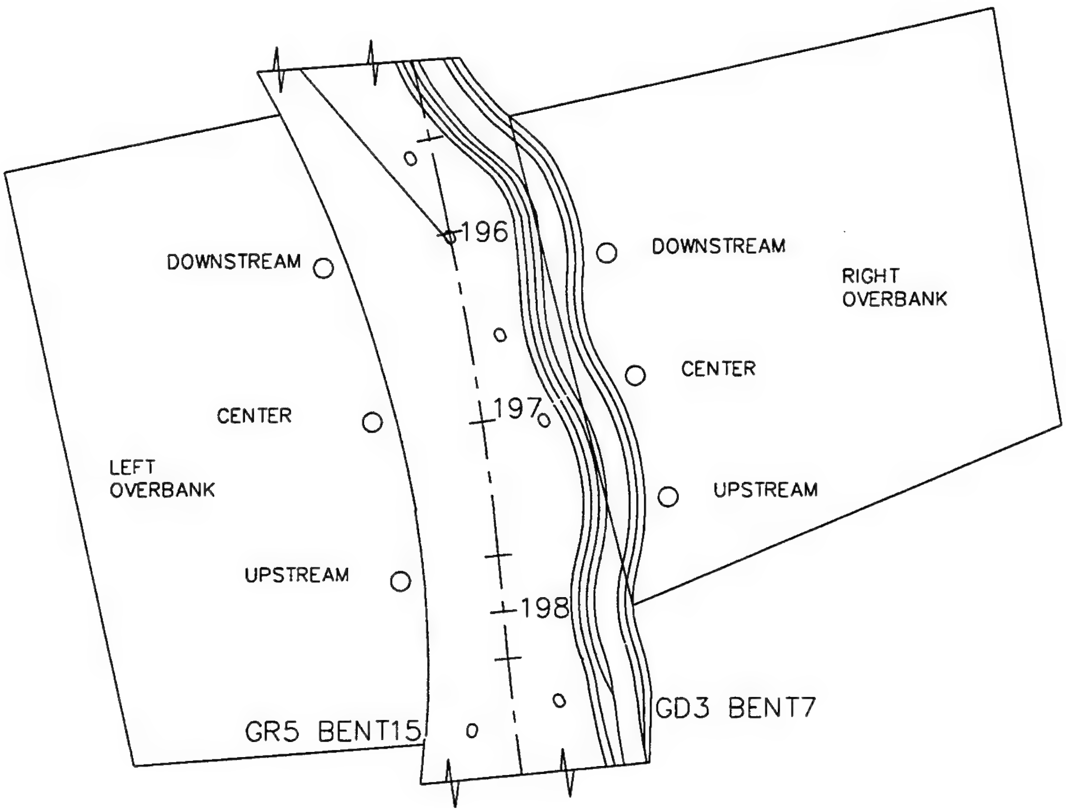

TYPE 19 UPSTREAM CHANNEL
TYPE 20 BYPASS ENTRANCE




PLAN VIEW OF
BRIDGE SOFFITT AT GR5 LINE




WATER–SURFACE MEASUREMENT LOCATIONS
TYPE 19 UPSTREAM CHANNEL
TYPE 20 BYPASS ENTRANCE

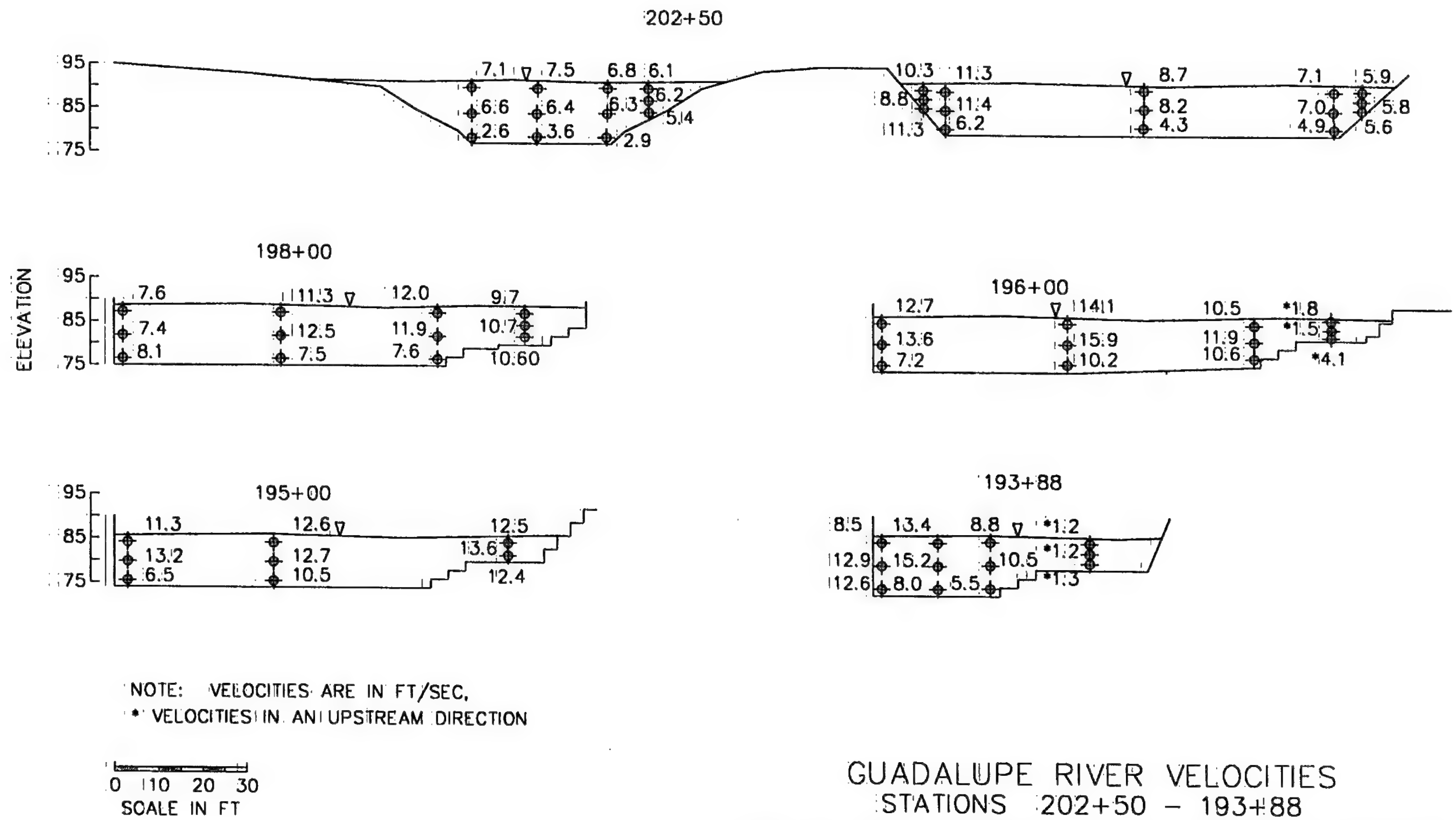



NOTE: FOR FUTURE FLOW CONDITIONS, FLOW BEGINS TO SPILL OVER ONTO THE OVERBANK AREAS WITH DISCHARGES GREATER THAN 14,600 CFS

LEFT AND RIGHT OVERBANK

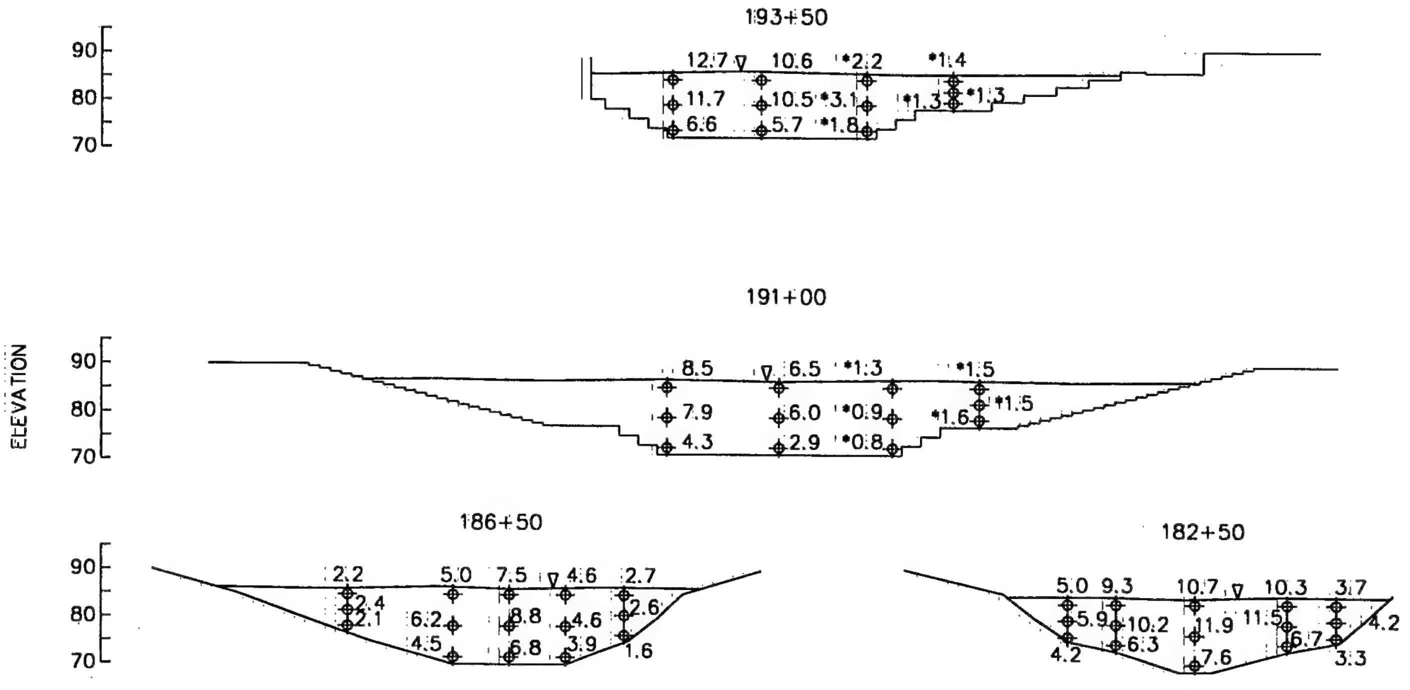
WATER-SURFACE ELEVATION

MEASUREMENT LOCATIONS




NOTE: VELOCITIES ARE IN FT/SEC.
* VELOCITIES IN AN UPSTREAM DIRECTION

GUADALUPE RIVER VELOCITIES
STATIONS 202+50 – 193+88
TYPE 19 U/S CHANNEL, TYPE 16 BYPASS ENTRANCE
FUTURE CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT STA 151+27 77.0




NOTE: VELOCITIES ARE IN FT/SEC.
* VELOCITIES IN AN UPSTREAM DIRECTION

0 10 20 30
SCALE IN FT

GUADALUPE RIVER VELOCITIES
STATIONS 193+50 – 182+50
TYPE 19 U/S CHANNEL, TYPE 16 BYPASS ENTRANCE
FUTURE CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT STA 151+27 77.0

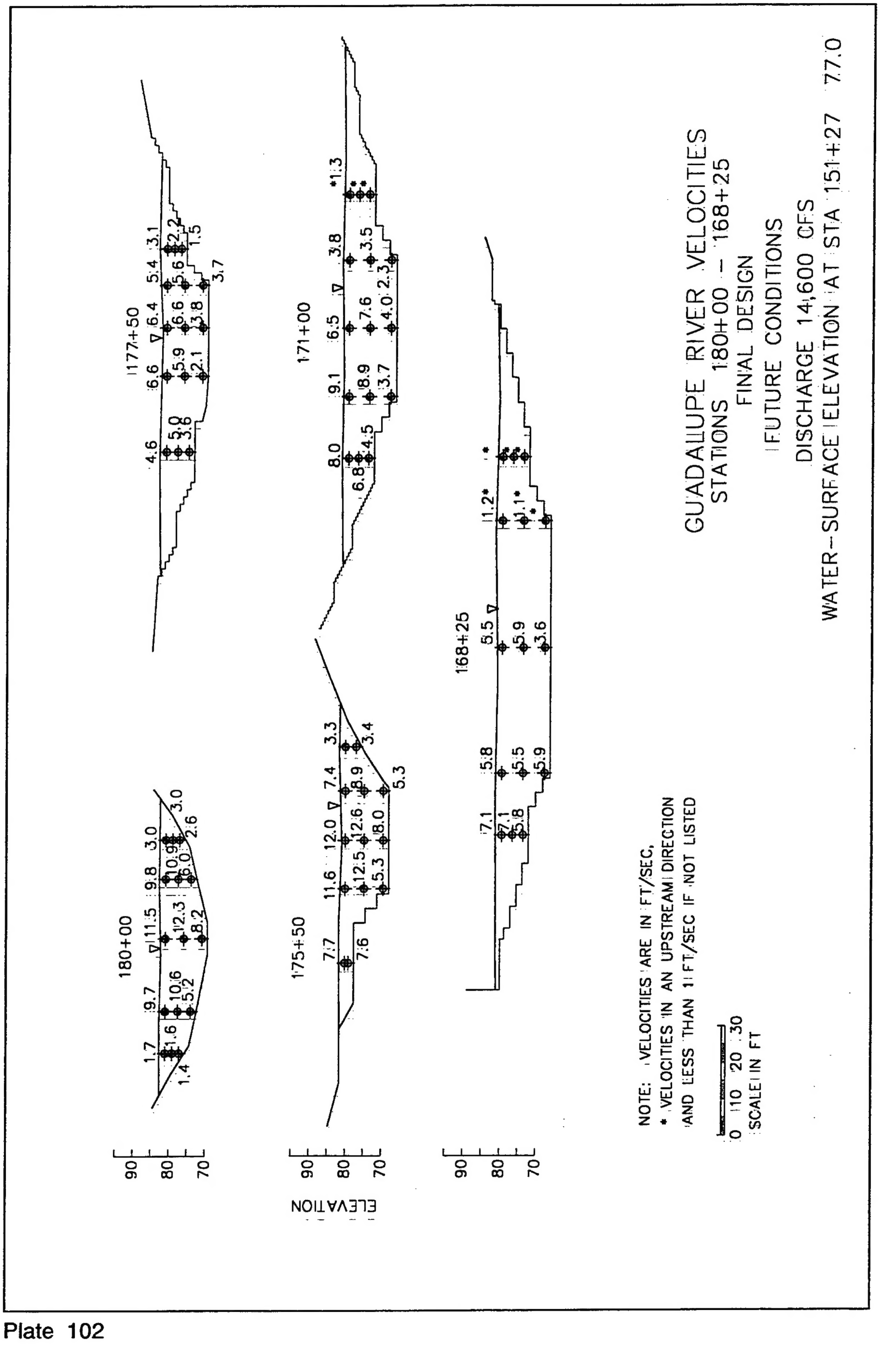
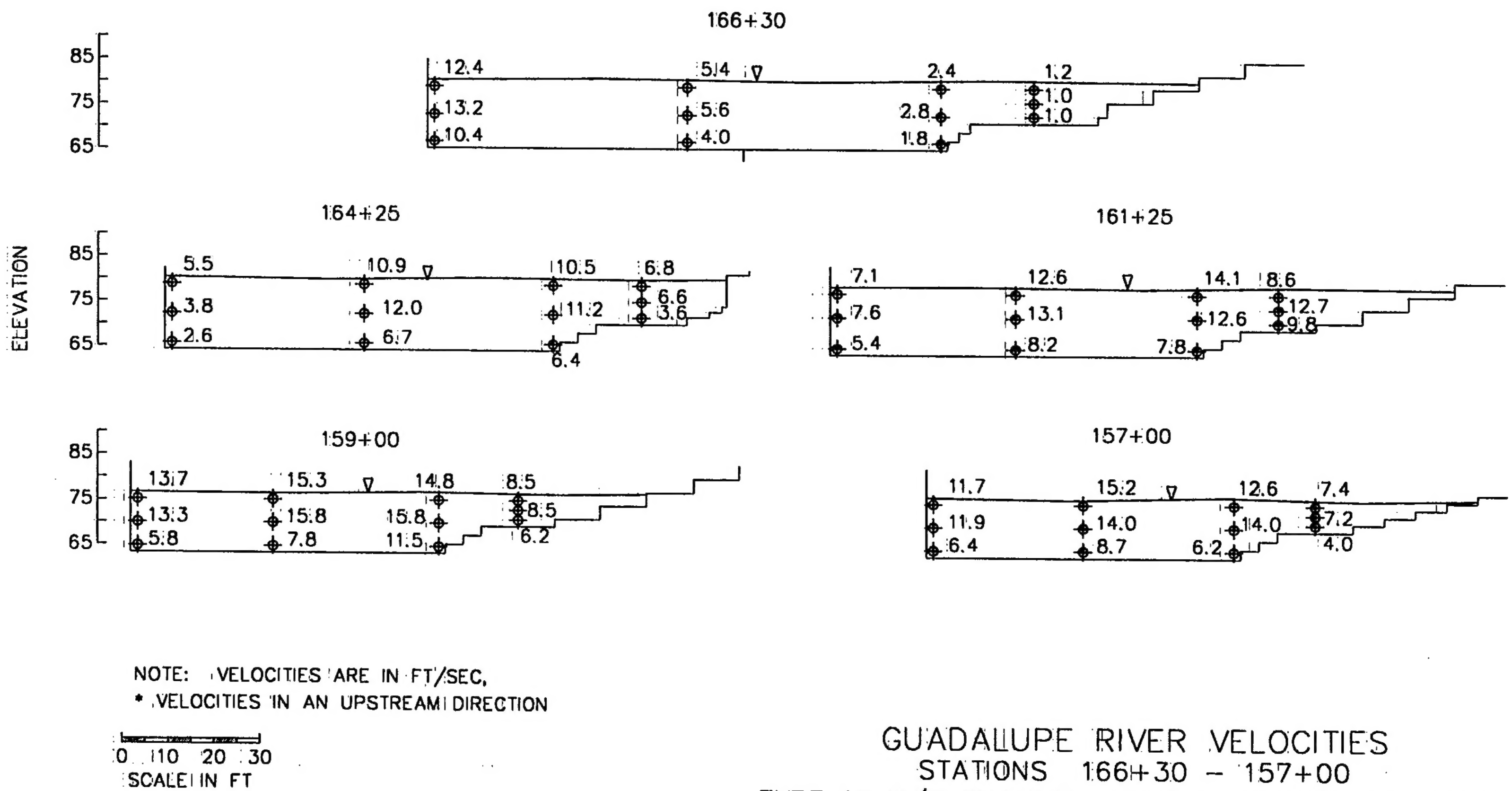
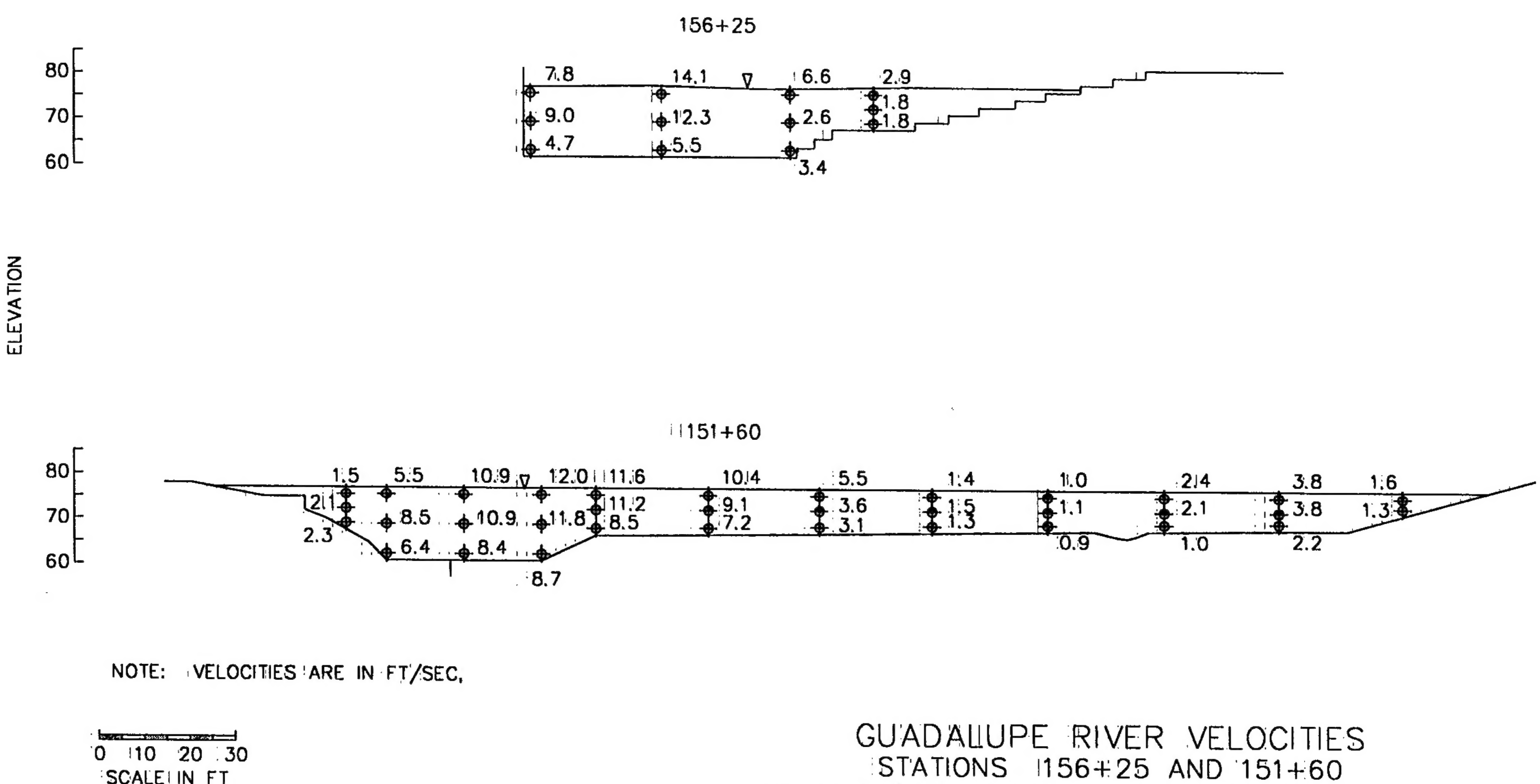

GUADALUPE RIVER VELOCITIES
STATIONS 180+00 – 168+25
FINAL DESIGN
FUTURE CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT STA 151+27 77.0
180+00
177+50
175+50
171+00
168+25
ELEVATION
90
80
70
NOTE: VELOCITIES ARE IN FT/SEC,
* VELOCITIES IN AN UPSTREAM DIRECTION
AND LESS THAN 1 FT/SEC IF NOT LISTED
0 10 20 30
SCALE IN FT

Plate 102




GUADALUPE RIVER VELOCITIES
STATIONS 166+30 – 157+00
TYPE 19 U/S CHANNEL, TYPE 16 BYPASS ENTRANCE
FUTURE CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT STA 151+27 77.0




GUADALUPE RIVER VELOCITIES
STATIONS 156+25 AND 151+60
TYPE 19 U/S CHANNEL, TYPE 16 BYPASS ENTRANCE
FUTURE CONDITIONS
DISCHARGE 14,600 CFS
WATER-SURFACE ELEVATION AT STA 151+27 77.0

# REPORT DOCUMENTATION PAGE

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**6. AUTHOR(S)**
John E. Hite, Jr.

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**13. ABSTRACT** *(Maximum 200 words)*

Numerous experiments were conducted to evaluate the flow conditons in the Guadalupe River and bypass culverts. The ultimate goal was to develop the desired flow split for the design discharge of 14,600 cfs while maintaining acceptable water-surface elevations in the upstream channel. The desired flow distribution was 55 percent of the flow down the bypass culvert with a total inflow of 14,600 cfs. This goal was achieved with many of the designs.

Pier extensions on the I-280 piers upstream and downstream from the bypass culvert were effective in reducing localized flow disturbances around the piers and would probably prevent some debris from accumulating on these piers. The pier extensions did not significantly lower the water surface in the upstream or affect the flow distribution between the bypass culvert and the Guadalupe River.

Many channel modifications were required due to seismic constraints and aesthetics. The final design will provide acceptable performance as long as the areas exposed to the high velocities are adequately protected.

**14. SUBJECT TERMS**
Bypass culverts
Flow conditions
Guadalupe River
Pier extensions

**15. NUMBER OF PAGES**
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**16. PRICE CODE**

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